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Topics of the Month

Tackling the chemical effluent problem

THE passing of the River Boards Act a few years ago with its promise of far stricter control over the discharge of industrial wastes into Britain's rivers and waterways came as a salutary check to a state of affairs which was fast becoming a national scandal. Many fine rivers and streams have been 'killed' by uncontrolled dumping of foul wastes and irreplaceable amenities have been destroyed. The problem of effluent disposal is a serious one for the chemical and allied industries in view of the advent of the River Boards with their powers to require higher standards of effluent treatment before discharge. It was for this reason that last June we published a special issue which surveyed the problem and discussed methods of treatment.

Some chemical firms are themselves taking the initiative in helping to keep the rivers clean. An outstanding example is Monsanto Chemicals Ltd., who, a few weeks ago, showed us the new effluent purification plant at their Ruabon (North Wales) factory. We unhesitatingly commend this plant as a model to any firm confronted with similar problems.

Monsanto's effluent problems could hardly have been greater. The factory makes phenol and salicylic acid, among other chemicals, and it produces a most difficult effluent. This must be discharged to the River Dee which, besides being one of the finest salmon rivers in Britain, also

supplies water to a large population around Chester. This water is taken from below the Ruabon factory.

The factory has been in existence since 1867, but it was only after the first world war that effluent became a problem. This problem grew with the expansion of the factory and in 1936 steps were taken to improve the disposal system. A percolating filter was installed but later abandoned as results were disappointing due to it being overloaded. In 1939 the pressing problem of disposing of sulphite liquor from the synthetic phenol plant was tackled by arranging for its pre-oxidation with diffused air in tanks.

Other measures, including impounding lagoons of 5,000,000-gal. capacity for controlled release of effluent, were taken, but it was not until after the war that the new scheme was started, consequent upon plans for considerably enlarging the factory. Biological filtration was chosen, a method which has been proved in sewage disposal.

Briefly, the process involves the passing of effluent substantially free from suspended matter through beds of stones impregnated with bacteria capable of oxidising organic materials not only of animal but also of chemical origin.

The system works as follows: Strong liquor and weak liquor pass to balancing tanks and storage tanks respectively and thence to a mixing tank. They are then neutralised by a lime slurry and flow to two primary clarifiers which extract

sludge. The liquors then pass through a manifold which distributes them to the six 100-ft. diameter percolating filters, each with four revolving arms through which the effluent flows and is evenly distributed over the complete surface of the filter bed. After recirculation and final clarification, the purified effluent flows into storage ponds for subsequent discharge to the Dee.

Although biological filtration is not a new method of effluent treatment, many problems had to be solved before it could be applied to the chemical effluents at Ruabon. The research and development necessary raised the total bill for the plant to £600,000, although it is estimated that the same plant could now be duplicated for half that amount. The chairman of Monsanto, Mr. E. A. O'Neal, Jun., has offered to make available to other British firms the data acquired during this research to help them with their own effluent problems.

This is a public-spirited gesture and it is in keeping with the spirit which animated Monsanto in building their admirable plant.

Microbes as chemical manufacturers

COUPLED with effluent purification is the elimination of waste in chemical manufacture. Monsanto regard this as part of their waste control scheme and they are now recovering some 9,600 tons p.a. of products that formerly went down the drain. In this way efficiencies are continually being improved.

This topic of 'wealth from waste,' once so popular during the war-time salvage drives but since then largely neglected even though the need remains, was taken up by the Secretary of the D.S.I.R., Sir Ben Lockspeiser, in a speech at the opening of the new effluent plant. Sir Ben doubted very much if we needed to throw away as much as we do and he commended the new approach of bacterial production of useful chemicals from effluents and also from the main products from which effluents are derived. The microbiological synthesis of chemical products was an expanding field and more work should be devoted to the selective breeding of micro-organisms. In short, said Sir Ben, man should now turn his attention to the microbiological 'jungle' to find and train organisms for his service in the same way as our primitive ancestors turned to the jungle and found wild animals, trained them to work usefully and bred them for useful characteristics.

More oil for industry

PETROLEUM is becoming an increasingly important fuel and raw material for industry in Great Britain, a remarkable fact in a country without significant indigenous reserves of oil and with an economy traditionally based on coal. Last year, oil consumption rose to nearly 17,000,000 tons, compared with about 15,250,000 tons in 1950. Even more striking was the rise in output from British oil refineries, from just over 9,250,000 tons in 1950 to nearly 16,500,000 tons last year. Compared with 1950, production of motor and aviation spirit more than doubled in 1951 to nearly 3,000,000 tons. Nearly half the total output of refined products was fuel oil—more than 7,500,000 tons, against 3,800,000 in 1950. As the new refineries are operating almost entirely on Middle East crude, this expansion in refinery capacity is saving millions of dollars.

Figures showing the growing value to industry of gas, diesel and fuel oil are impressive. The steel industry, for

example, used nearly a million tons of oil last year. This trend towards oil firing in the steel industry in place of producer gas is likely to continue, as pointed out in the note on steel productivity in another column (see also our note in February 1952, p. 69). The gas industry, too, is using greater quantities of oil, 556,660 tons, against 539,611 tons the year before. As will be recalled (this journal, March 1952, p. 120), the use of butane as town's gas is being tried experimentally in Wales and there is a likelihood that this refinery gas will be used more widely as a household fuel.

Aluminium's new horizons

THERE has been a serious lag in the development of aluminium production in the sterling areas and Europe as opposed to that of North America. In 1939, sterling area production was 171% of that in North America. Last year it was only 30%, and it is estimated that in 1953 it will be down to 20%. This has been brought about in the first instance by changes arising during the war when conditions for expansion, particularly in relation to available power, greatly favoured North America. These conditions have continued to operate since the war and have been accentuated by the greater political stability of this area in relation to many possible areas of production available elsewhere. The result is that aluminium production in the non-dollar areas is not meeting current increased demands, whereas in the U.S.A. the metal is said to be so plentiful that certain restrictions on its uses have been withdrawn. In fact, there is for the first time enough aluminium for major potential users to consider its application on a large scale. Even so, aluminium production capacity is to be increased still further in the U.S.A. and Canada.

In 1939, U.S. aluminium production was about 150,000 tons p.a. and all of this was made by Alcoa. Recently the Reynolds Metals Co. opened a new 72,000 tons p.a. plant on the Gulf Coast and, when its reduction plant at Arkadelphia is completed, this company's total aluminium production capacity will be about 370,000 tons p.a., some 2½ times the whole U.S. pre-war production. In addition, the two other leading U.S. producers, Alcoa and Kaiser, are expanding production facilities. A common feature of these projects is the departure from hydroelectric centres made possible by the development of alternative sources of cheap fuel. For instance, Reynold's new plant burns natural gas, requiring 40,000,000 cu.ft. day. Kaiser's new plant at New Orleans also uses natural gas. Lignite will be used at the Alcoa plant nearing completion at Rockdale, Texas.

In Canada, too, the already well developed aluminium industry is being enlarged. A \$550,000,000 project is being undertaken by the Aluminium Co. of Canada near Kitimat, British Columbia, which includes an aluminium plant and a 1,600,000-h.p. hydroelectric station. This project will also open up timber development in the area.

Meanwhile, the non-dollar areas are now beginning to recover some of the initiative in aluminium development. A major project is being planned for the Gold Coast, which has reserves of bauxite estimated at about 225,000,000 tons. It is expected that about 1,150,000 tons of bauxite will be processed annually into 210,000 tons of aluminium. A dam will have to be constructed across the Volta River about 70 miles from Accra, creating a 2,000 sq. mile artificial lake, one of the largest in the world. A 550,000-kW hydroelectric power station will be constructed, providing 500,000 kW for the operation of the aluminium smelters, the balance being available for public use. The whole project includes

the building of new roads and railways and a new harbour, the latter alone requiring a labour force of 23,000 men. This Volta River project is an Anglo-Canadian enterprise which is being planned by the British Aluminium Co. Ltd., Aluminium Ltd. of Montreal, and the U.K. Government.

Canada is also affected by plans for aluminium production in Dutch Guiana, the world's largest source of bauxite. If they materialise, the Netherlands will then obtain aluminium from Dutch Guiana instead of Canada. However, this is expected to have little effect on Canada's industry. Bauxite production in Dutch Guiana has been rising steadily during the past 13 years and exports may substantially exceed 3,000,000 tons p.a. during the ten-year development programme starting this year. It is expected that a minimum of 100,000,000 Surinam guilders (\$53,000,000) will be required between 1952 and 1962 to exploit the bauxite deposits and introduce actual aluminium production in this South American colony.

The first chemical society

WHICH was the world's first chemical society? There was some controversy about this until 1935 when it was established that the first chemical society in the world was founded in 1785 in the chemistry department of the University of Edinburgh, under the sponsorship of the famous Joseph Black, professor of chemistry at Edinburgh and renowned for his work on magnesia and on latent and specific heat. Until recently the only evidence for the existence of this historic society was a list of its 59 original members. In 1947, however, Dr. McLaughlin, of St. Patrick's College, Maynooth, discovered in the archives of the Royal Irish Academy, Dublin, a volume which examination showed to be the first volume of the *Proceedings* of the Edinburgh University Chemical Society. A well-bound folio of 452 pages in copper-plate manuscript, it contains 32 dissertations on topics of chemical interest. Antedating by five years the *Annales de Chimie*, initiated in Paris in 1790, it can claim to be the first journal of a purely chemical character in the world. Through the courtesy of the Council of the Royal Irish Academy, it has now been returned to its original owners.

Prof. James Kendall commented on these *Proceedings* in his recent presidential address to the Royal Society of Edinburgh on 'The First Chemical Society, the First Chemical Journal and the Chemical Revolution.' In his view, although the communications presented are not of major scientific importance, they do afford a unique record of contemporary chemical thought. In particular they disclose one fact of significant historical interest, namely that Joseph Black, commonly regarded as among the last to accept the 'chemical revolution' of Lavoisier, must have been among its earliest advocates, since the majority of his students were already converts to the oxygen theory of combustion in 1785-86. The penultimate paper, by Mr. John Carmichael, merits special consideration. It consists of a violent attack upon the long-established doctrine of phlogiston, which Lavoisier overthrew, and concludes with a quotation from Virgil applicable thereto: *Venit summa dies* (Its last hour has arrived). That pronouncement was obviously endorsed by Mr. Carmichael's colleagues, since on the title-page of his medical graduation thesis in 1787, where he continues the attack, he proudly announces himself as 'Extraordinary Member and President for the Year of the Chemical Society of Edinburgh.' This thesis was almost certainly one of two sent by Black to Lavoisier in

1790 as proof that Edinburgh students, while enjoying 'the most perfect liberty of chusing their philosophical opinions,' had in general embraced his system.

Incidentally, Mr. Carmichael was one of the few original members of the Society who was a native Scot. The nationality of 19 has been traced: only three were Scots, three were English and thirteen Irish! Presumably one of this formidable Irish fraction was responsible for the transfer of the first volume of the *Proceedings* to Dublin.

Nuclear research in Europe

TEN European countries have sensibly decided that, instead of carrying out strictly national programmes of nuclear research, they should co-ordinate their efforts under the aegis of a new body, the European Council for Nuclear Scientific Research. At meetings in Copenhagen in June, it was agreed to build a nuclear research station in either Denmark or Switzerland.

Four groups will be appointed to plan the building of the research station. Mr. Odd Dahl, of the Chr. Michelsen Institute in Bergen, Norway, was appointed as head of the group to plan the building of the cosmotron, the atom-disintegrating machine, which will produce nearly 15,000,000,000 V, weigh 8,000 tons and cost about £5,000,000. According to Mr. Dahl, the laboratory building should be ready in about three years' time, while the erection of the main machinery will take from six to seven years.

Great Britain is not a member of the new Council, it having been decided, presumably, that we are so far ahead in our nuclear energy programme that no advantage would be obtained from the co-operative scheme. Nevertheless, Liverpool University has offered research facilities to European physicists and engineers, including the use of the 400-MEV cyclotron which is now under construction. This co-operation is all to the good and it is to be hoped it will be extended to reactor studies.

The countries taking part in the scheme are Belgium, Denmark, France, Germany, Italy, Holland, Sweden, Norway, Switzerland and Yugoslavia.

Iron and steel productivity

SINCE the war the British iron and steel industry has achieved an increase of 25% in the output of finished steel per man employed. This is no small achievement, particularly as the cost of making iron and steel in Great Britain remains low by international standards. In spite of this, productivity in the British industry is lower than in the United States. Last year a team under the leadership of Sir Charles Goodeve, Director of the British Iron and Steel Research Association, visited the U.S. to discover the reasons for this higher productivity, and last month they issued their report ('Anglo-American Council on Productivity,' London, 5s., post free).

Broadly, the American industry leads Britain and, indeed, the world in productivity for four main reasons: larger units of plant in larger works, greater purity and abundance of raw materials, faster driving of plant, and the use of high-grade fuel, including oil and natural gas. These are formidable advantages, especially when coupled with the fact that the Americans have a market six times bigger than the British. This has led to greater standardisation than seems possible of achievement in Britain, owing to the fact that a larger proportion of our iron and steel is exported, thus demanding considerable variations in standards.

The advantages the Americans have in raw materials can be simply stated: the average iron content of their ores is 50%, compared with 40% in the U.K. The use of more of the richer imported ores would obviously increase British iron-making plant, fuel and labour productivities, and steps to achieve this are, in fact, being taken. It is in this respect that the chemical engineer can make a great contribution to the industry, for much remains to be done in ore treatment and beneficiation, both for imported and home ores, in spite of the fact that Britain has been at least as progressive as America in this field.

American coking coal is on the average of better quality than British and it is easier to mine and relatively cheaper than in Britain. For open-hearth and mill furnaces, America has the enormous advantage of abundant reserves of cheap oil and natural gas, which are piped to most parts of the country. The effect of these rich fuels on productivity is shown by the fact that about 25% of British open-hearth steel production has been converted within the past five years from producer gas to oil firing with an increase of 10% in furnace outputs. In British soaking pits and reheating furnaces there is considerable scope for improvement in fuel consumption rates.

American steel works plant is driven at high rates. To a large extent this is attributable to the purity of raw materials and fuel, to size of plant units, and to other characteristics peculiar to the American industry. But even after allowing for these, American steel workers are still able to get 10 to 20% more out of each unit of plant than is achieved in Britain. In blast furnaces this is accomplished with some increase of coke consumption, which the Americans can afford, and in open-hearth furnaces with a reduction in roof life, which they accept. The rolling mills, however, seem to take fast driving with little if any increase in shut-down or maintenance costs. Here is no case for a blind following of American operating rates, but there is a case for a continuous study of all modern methods to increase the operating rate of each individual piece of plant.

Research in the American steel industry is on a relatively small scale, owing perhaps to the comparatively simple metallurgical problems in that country. Ferrous metallurgical research in America as a whole is on an extensive scale and receives considerable financial assistance from the Government and from the using industries. Co-operative research in Britain has been found to be an efficient way of increasing the technical strength of the industry, and is on a much larger scale than in the U.S.

Finally, the team discuss the fiscal advantages enjoyed by the American industry. American firms are allowed by the Government to write off capital cost of plant and buildings more rapidly than are British firms. The capital cost of an integrated steel works on a new site is estimated at £75 per ingot ton of capacity; unless the higher capital charges involved in new investment are more than offset by the operating economies secured through an increase in plant or labour productivity, then productivity in its widest sense has declined. Even after taking account of this factor the team urge a continuation of at least the current expenditure by the British steel industry. At present prices £30,000,000 must be spent each year merely to maintain existing capacity. Plans are, however, now being made to increase the present capacity, and the team consider that an annual capacity of around 20,000,000 ingot tons could be reached in a reasonable time only if annual capital investment of £60,000,000 is maintained or even exceeded.

Iron oxides from wastes

PIGMENT grade iron oxide in red and yellow colours as well as other intermediate shades can now be salvaged from iron-containing waste solutions in batch and continuous wet chemical processes devised in the U.S. Involved in these processes are two newly developed pilot plants consisting of simple equipment and controls that provide automatic operation. Developed out of the urgent need for better methods of producing iron oxides, the two pilot-plant systems have a production capacity of 400 lb. day, chemically producing stable and reproducible oxide materials that require no further grinding or conditioning for pigment use. While the continuous operation has proved superior to batch processing, design studies of an 8-ton commercial plant based on the pilot model indicate the process to be economically feasible for small- or large-scale use of the various liquor wastes produced in iron or steel processing.

Both processes produce a high yield of finished pigments that are clear in colour, have a high tinting strength and a high oil-absorption value which permits satisfactory rubbing up with drying oils, according to an article in *Industrial and Engineering Chemistry*. Dried films of these oxides used in oil are homogeneous and opaque.

Research on synthesising iron oxides has shown the wet chemical method to be the only technique capable of producing wide colour variations. The method involved precipitation of a ferrous or ferrous-ferric hydroxide, or other hydrogel, followed by oxidation of this hydrogel or the original salt to a known ferrous-ferric content; and conversion, with or without a catalyst, of the hydrogel or original salt by heat and pressure to the desired form of ferrous-ferric or ferric oxide.

The pilot plant for batch production of red oxide consists of a heat exchanger designed to handle suspensions of solids without undue fouling and without corrosion, a pump to circulate the hydroxide-oxide suspension through the heat exchanger and remainder of the system, a holding drum designed to withstand pressure operation and of sufficient capacity to produce the desired time-space relation, and a temperature control to hold the system temperature at predetermined values. A separate tank is used for mixing and introducing solutions into the system.

The equivalent pilot plant for continuous production requires, in addition, a bellows-actuated differential air relay to the holding tank with taps at top and bottom, a proportional acting liquid level indicator-controller that controls an air-operated valve placed in the batch sampling line between the pump discharge and the heat exchanger inlet, a disengaging drum that also functions as a decanting barrel in concentrating the finished pigments, and a charge pump that meters the fresh feed-precipitated iron solution to the system.

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Automatic Process Controllers

By Alan Pollard, B.Sc., A.R.I.C.

This is the second article in the series on automatic control in the process industries, the first of which appeared in **CHEMICAL & PROCESS ENGINEERING** in July. The author first discusses the advantages of pneumatic and electrical control instruments and then describes in detail four post-war designs by British manufacturers. Three of these instruments are pneumatic and the fourth is electrical. In the third and last article, the author will deal with graphic and supervisory control panels.

A VERY wide range of automatic instruments for process control is now available. Many of these are of the directly-actuated mechanical type and often are not regarded as controlling instruments in the accepted sense, *e.g.* pressure-reducing valves and float-operated level valves are effectively fixed band proportional controllers in action. If this type of apparatus is excluded from consideration, by far the greatest majority of automatic process controls are found to be pneumatic in operation. In fact, until very recently, for any application requiring a continuous control action there was no real alternative to the air-operated instrument. Electrical process controllers in the past have been essentially discontinuous in action and so unsuitable for many process applications. Hydraulic instruments, although capable of developing continuous actions, have not been developed to such an extent as the pneumatic type, and are thus restricted in application, mainly to those situations requiring the movement of heavy loads, *e.g.* automatic boiler control and the gas industry. In general process work the use of hydraulic equipment is almost entirely restricted to auxiliary power positioning in conjunction with pneumatic controllers.

The pneumatic controller

The reasons for the predominance of the pneumatic controller are partly historical and partly practical. Historically, automatic control in the process sense was born, and indeed has been developed almost entirely, in the American petroleum industry where the first requirement of any new apparatus is freedom from fire and explosion hazards. It was therefore natural that attention be directed to the intrinsically safe equipment, of pneumatic, hydraulic or direct mechanical operation. Of these alternatives, pneumatic operation is by far the most flexible in use and lends itself particularly well to centralised control systems where the transmission distances are not excessive. The pneumatic design also proved more successful than its competitors, including the electrical instruments, in that the addition of the integral and derivative actions, as these were developed, required only relatively simple modifications to the basic proportional controller. Pneumatic instruments are also simple in construction and inexpensive in

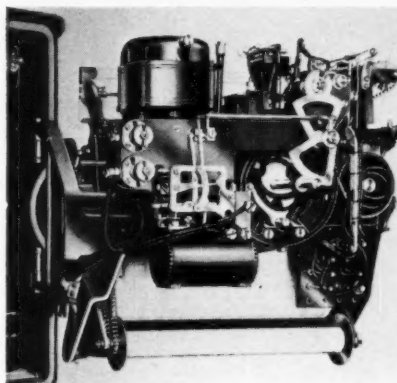


Fig. 1. 'Mark 20' controller mounted in the 'Multelec' potentiometer.

maintenance if the operating conditions are at all reasonable.

The principal disadvantage of the pneumatic controller is the effect of transmission lags when the controller is separated from the plant. The modern practice of centralised control rooms, well away from the operating area, has necessitated the pneumatic transmission of signals from the plant, as well as the transmission of the

controller output signal to the regulator. This adds to the control loop two significant transmission lags and thus makes control more difficult. A recent development to remedy this defect is the use of close-coupled circuits in which the controller is situated on the plant, as close as possible to both the measuring and regulating units, thus reducing the transmission lags to a minimum. The controller is then linked pneumatically to a supervisory instrument in the control room, from where the desired value can be adjusted and the performance monitored on a recording instrument. It is not possible in the present designs to adjust the control actions from the control room, but on a continuous process this should rarely be necessary once the plant is in operation.

There is also an inherent feature of all existing pneumatic controllers, with one exception, which may prove to be disadvantageous in the future, although at the moment, with the present application techniques, it is not a serious disadvantage. This feature is the mutual inter-action of the integral and derivative generating systems upon each other and on the proportional action. The effect is only found in the three-term instrument, but due to the different methods of generating integral action, the effects of interaction differ between instruments of different manufacture. Each particular instrument must be considered on its individual design, and it is to be regretted that some of the essential information does not always appear in the manufacturer's instructions. A theoretical analysis of this subject has recently been presented by Rutherford and Aikman¹ and the practical aspects by Young.²

In practice the effects of inter-action are threefold, *viz.*:

(1) The amounts of the integral and derivative action shown on the controller adjustments are not those which are actually generated by the instrument; both actions are generally reduced in magnitude. In some cases it is possible to relate the effective actions to the nominal, depending on the controller design.

(2) The proportional band is also reduced by the inter-action, that set on the controller being effectively divided by an 'inter-action factor' which is dependent on the ratio of the nominal derivative and integral actions. This is probably the most important prac-

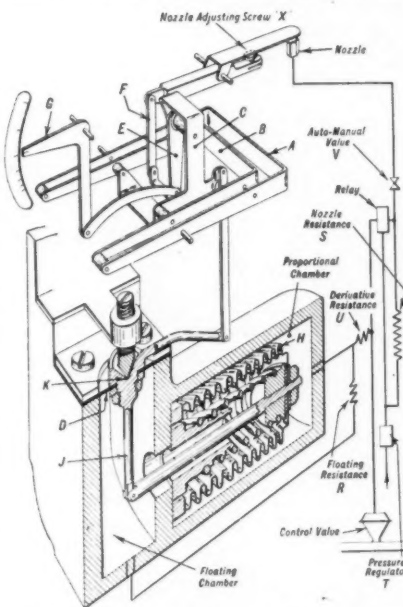


Fig. 2. Sectional diagram of the 'Mark 20' controller.

tical effect, since reduction of the proportional band tends to make the control system unstable.

(3) The inter-action limits the maximum effective ratio of derivative to integral action, and thus the amount of derivative action—needed to improve the recovery time—is limited.

So long as the effects of interaction are recognised, its presence is not a serious disadvantage. It would simplify the setting up of a controller if the effective actions were directly readable, since these values should theoretically be related to the period of oscillation of the controlled variable. But by maintaining a constant ratio of the nominal action times, the inter-action factor also remains constant and there can be no further change in the proportional band. Some makers have adopted the expedient of linking the derivative and integral adjustments to maintain the optimum ratio corresponding to the maximum derivative action.

It is, however, apparent from the continual improvements in the design of the pneumatic controller that the manufacturers recognise the need for improving the stability and ease of setting of the controller adjustments. Advances in application technique and the requirements of greater precision in control make increasing demands on the need for stability of calibration and reproducibility of the integral and derivative action generators. It is in this direction that the major advantages of the new electrical controllers lie, since this stability and reproducibility should be more easily provided by electrical components.

Nevertheless, the pneumatic controller, free from any flame-proofing requirements, with ample power to operate all but very large or high-pressure valves, and with fittings that can be neatly assembled into standard panels and also into the newer graphic panels, is still capable of meeting all the present needs of process control. This state of affairs is likely to continue, and it is generally felt that the pneumatic controller will maintain its present predominance for some time to come.

In the post-war years many of the early types of controller developed before the war have been remodelled and their performance improved. There have also been several new instruments, some of which differ quite radically from their predecessors. In this article three of these newer instruments are described, attention being restricted to the three-term instrument in each case, although it will be readily appreciated that in most cases the simpler instruments are also available.

The 'Mark 20' controller

This was the first controller of post-war design to appear on the British market and it is made by George Kent Ltd. The controller itself is a pneumatic unit of remarkably small dimensions which can

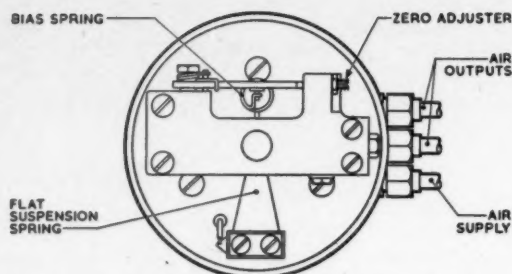


Fig. 3. Constructional details of the 'Eltair' electro-pneumatic convertor.

be installed in any of the standard range of Kent measuring instruments. Fig. 1 shows the unit installed in the *Multelex* potentiometric instrument used for the control of temperature, pH, etc. The control unit is linked to the measuring element by a direct mechanical linkage and the operation is illustrated in Fig. 2. The basic element is the conventional flapper and nozzle system, the flapper being linked differentially to the measuring unit and the desired value setting by the U-members A and B. The movement of the flapper is restricted to the throttling range of the nozzle (0.0008 in.) by the opposing movement of the bellows H subjected to the controller output pressure, transmitted through the linkages J and C. The proportional band is changed by altering the lever ratio of the pneumatic feedback mechanism through the quadrant linkage G. The range is adjustable from 1 to 650%, probably the widest range available in an instrument of the conventional pneumatic design. Derivative action is generated in the usual way by a restriction in the air line to the feedback bellows. Integral action (referred to as 'floating' in the diagram) is generated by equalising the pressures across the bellows by a second restriction (R), the integral side of the bellows being sealed by the diaphragm D, through which the bellows displacement is transmitted. The two restrictions are glandless micrometer valves which do not form part of the unit but are mounted adjacently as shown in Fig. 1, the connections to the unit being made by

flexible air lines. Both micrometers are scaled arbitrarily in units of needle travel, but can be related to the nominal integral and derivative action times. The relay valve is of the non-bleed type and is combined with a pressure regulator and is mounted externally to the controller.

The Mark 20 controller has been used very successfully under the rather exacting conditions of the steel industry, in the control of soaking pits and open-hearth furnaces, and has also been applied to boiler control and gas producer control.

The 'Trimode' controller

This instrument, manufactured by Elliott Bros. Ltd., belongs to the newer category of controllers which are not connected mechanically to a measuring instrument, but are located remotely. The manufacturers have in fact referred to the instrument as a 'blind' controller, the *Trimode* unit being regarded as a computing device which imposes integral and derivative components on the output of a simple proportional action generator. The unit must, of course, be supplied with a deviation signal from a conventional measuring unit, but the transmission may be either pneumatic or electrical. In the former, the transmitting unit is used with a proportioning relay which in effect multiplies the input pressure by a given amount, the proportional band being variable over a range of 2 to 400%.

In the electrical transmission system, the measuring unit is designed to produce an electrical output signal proportional to the deviation, and this is supplied to the electro-pneumatic convertor (the *Eltair* unit). This unit is shown in section in Fig. 3, and consists of a central rod carrying a moving coil in the air gap of a cylindrical pot magnet. At each end of the rod is a ball and cone valve, each being connected to the same air supply through identical restrictors. The unit operates on the force-balance principle: the electrical signal to the coil causes a vertical displacement of the rod, thus causing an increase in back pressure at one ball valve and a reduction at the other until the resultant pneumatic force re-balances the electrical displacing force. The total travel of the moving parts is about 0.008 in., and over about 80% of the range the output pressures are proportional to the input current. The unit can thus be used as a simple proportional controller by feeding the output from either end to a control valve, the proportional band being varied over a range of 2 to 200% by inserting a variable shunt resistance across the moving coil.

When the additional control actions are required, the *Trimode* unit is used, into which the convertors are integrally mounted, as shown in Fig. 4, where the electro-pneumatic convertor is the unit on

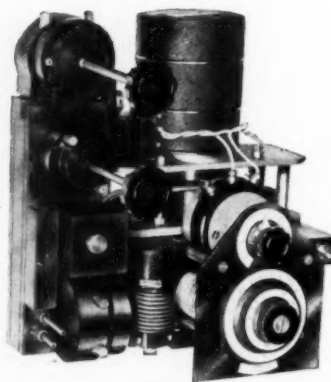
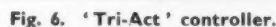


Fig. 4. 'Trimode' control unit.

The instrument is also rather unique in being of unit construction throughout. All the sub-units, including the air relay valve and pressure regulator, are plugged into

The instrument is shown in section in Fig. 7; it is non-indicating and must be supplied with air pressures in the usual standard 3 to 15 p.s.i. range, proportional to the measured and desired values of the controlled variable. The first necessitates a pneumatic transmitter at the measuring instrument, the latter being supplied from a pressure regulating valve generally combined with a supervisory instrument of the *Transet* series. These two air pressures are supplied to the diaphragm chambers 1 and 2 in the lower part of the instrument. It will be seen that the exposed areas of the diaphragms forming the upper and lower walls of these chambers are unequal and, consequently, any deviation of the measured value causing a difference in pressure between the two chambers will cause a deflection of the diaphragm stack. Equilibrium is established by balancing the upward and downward forces over the system. The resultant force due to the deviation may be in either direction, and is opposed by the upward force of the spring and the downward force supplied to the chamber 3 by the back pressure of the nozzle 4, the flapper of which is positioned by the movement of the diaphragm stack. Assuming there is no deviation, the pressures in chambers 1 and 2 would be equal, and the pressure in chamber 3 would then just balance the spring force which is manually adjusted to be approximately 9 p.s.i. It will be seen that the lower unit is effectively a simple proportional generating unit, the chamber 3 providing the proportional feed-



The variable proportional band of the instrument is derived from the pneumatic relay valve mounted immediately above the first-stage unit. The output pressure from the first unit, the back pressure of the nozzle 4, is passed through the capillary restriction 6 to the diaphragm chamber 7 and through the needle valve 10 to the upper unit of the instrument. Assuming that this valve is closed, any change in the output from the lower stage is completely imposed on the diaphragm 7, causing a maximum change in the back pressure of nozzle 8 and a maximum change in output through the line 9. The instrument is thus operating at a very narrow proportional band and, if the system is followed through to the air relay valve 13, it will be found to give effectively on-off control. Assume now that the valve 10 is opened to an intermediate position and that a similar change in back pressure occurs at the nozzle 4, this pressure now begins to leak through the valve 10, resulting in a smaller pressure change in the line 9 than occurred when the valve was closed. The proportional band has thus been effectively widened, or the sensitivity or 'gain' of the system reduced. It is interesting to consider the effect of completely opening the 'gain' valve 10 so that it affords no restriction to the flow of air. It can be seen that theoretically this would mean no

change in the output pressure irrespective of any changes in the output from the lower unit, i.e. an infinitely wide proportional band or zero gain. This is not, of course, possible in practice, but the instrument is capable of generating a proportional band very much wider than any instrument of conventional design, of the order of 5,000%.

The final stage of the circuit is provided by the upper unit: the output of the proportional unit is fed to the chamber 11, whose diaphragm is displaced against the spring pressure, thus varying the back pressure of the nozzle 12. This pressure, fed to the chamber 14, controls the output of the relay valve 13, either admitting air from the supply through the lower port or venting air to atmosphere to the upper port. The relay valve output is passed directly to the control valve and also to the chamber 15 as proportional feedback with, as in the lower diaphragm stack, a fixed proportional band. The chamber 16 opposes the proportional feedback and thus provides the integral or 'reset' action. This chamber is connected to the capacity chamber 17 and through the needle valve 18 (the 'reset' valve in Fig. 6) to the controller output. This integral feedback may be derived by a connection to the controller output within the instrument itself, or externally from the control valve when the instrument is used with an 'automatic-to-manual' change-over unit. The action of the whole instrument can be reversed very simply by changing the connections of the measured and desired value pressures; this is accomplished by reversing a plate on the bottom of the controller manifold which changes the internal connections directly.

It will be seen that the operation of the unit is also a departure from conventional practice. The controller operates with three proportional bands, two of which are fixed, and the derivative and integral actions are associated with different bands. In particular it should be noted that the integral action is combined with the last proportional band to be generated; it does not, therefore, 'reset' the other two bands, one of which is combined with the derivative action. This order of operation does not eliminate the effects of interaction; the controller operating equation can be shown to exhibit an inter-action factor, and the nominal action times can be related to effective times. The method of operation does, however, lead to a significant improvement in the quality of control when the instrument is used during the starting up of a process. With a normal controller using integral action, severe over-shooting of the desired value will occur due to the 're-setting' of the proportional band above the desired value. In the present case, only the final proportional band is 'reset' and the over-shooting is considerably limited, without, however, impairing the quality of control after starting up. This

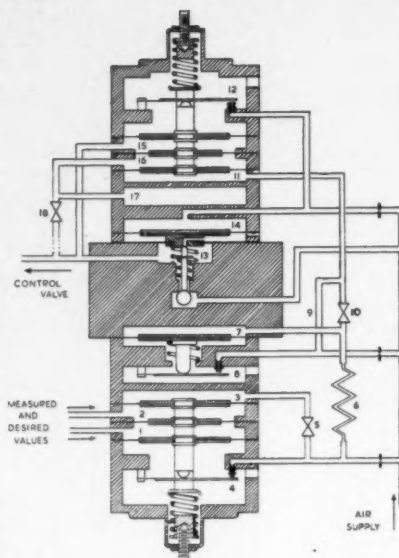


Fig. 7. Sectional diagram of the 'Tri-Act' controller.

aspect of the operation has been discussed in greater detail by Clarridge.³

It will be appreciated that the *Tri-Act* controller is essentially a three-term instrument and is not adaptable to the simpler forms of control. An interesting development of this instrument is the *Bi-Act* controller, which, as the name suggests, is a dual function controller, proportional-plus-integral, and of similar diaphragm stack construction. The unique feature is that the two control action adjustments are combined in a single needle valve, adjustment of which increases the integral action and widens the proportional band simultaneously. To set the controller to the process it is thus only necessary to make this one adjustment until a suitable degree of stability is obtained. The *Bi-Act* controller is not, however, yet in production for the British market.

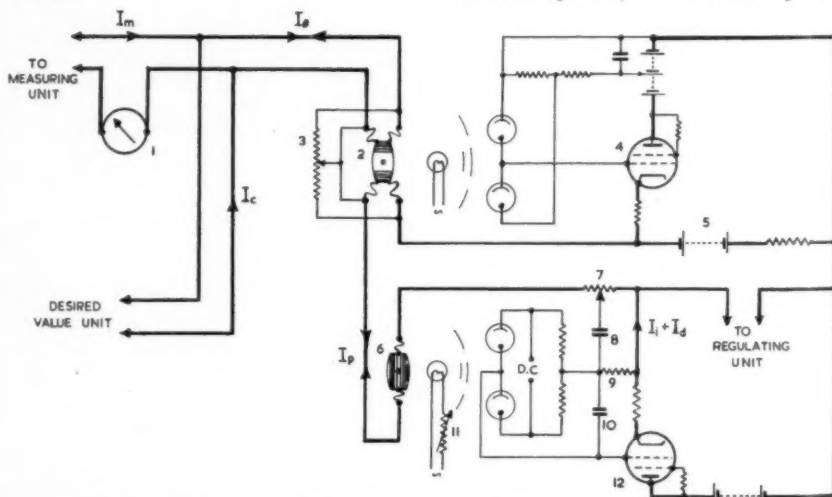


Fig. 8. Simplified circuit diagram of the 'Mark II' electronic controller.

Both these instruments are control units of the *Transet* series of instruments, and can be used with a variety of transmitting and supervisory instruments which are particularly intended for use on the 'graphic' type of control panel, to which further reference will be made in a later article.

Electrical controllers

Until very recently electrical process controllers have been confined to operations where discontinuous modes of control, i.e. two- or multi-position or fixed-speed floating control, could be used. These types of action only require the addition of switching contacts into the measuring instrument. It is also relatively easy to generate a proportional action electrically, but is much more difficult to generate integral and derivative actions with the relatively very long time constants (of the order of several minutes) required for process control. Several ingenious mechanisms were developed before the war to generate these actions, but due to their complexity and the general objection of flame-proofing requirements, the electrical instruments have never been regarded as serious competitors to the pneumatic controllers.

However, with the recent improvements in electrical techniques, particularly in the related field of servo-mechanisms, and the improved design and stability of components such as condensers, etc., an all-electric three-term controller can now compete effectively with the pneumatic controller, having in fact several advantages over the latter. These advantages include:

- (1) The complete elimination of signal transfer lags over virtually any distance.
- (2) All the control adjustments are made on wire-wound voltage dividing resistors, which can be calibrated with high accuracy and reproducibility.
- (3) The adjusting resistors can be removed from the controller proper and mounted separately on a control panel,

etc., the controller being mounted in standard electrical component racks and connected by multi-core cables.

(4) The control actions within the instrument are entirely independent of each other and there is no inter-action.

(5) The electrical components of the controller can be linked readily by plugs and sockets, so that for servicing, replacement units can be plugged in and the 'out-of-service' time cut to a minimum.

(6) The measured value of the controlled variable is transmitted as an electrical signal; it can therefore be subjected to such manipulation as extraction of the square root or addition to other similar variables by standard electrical techniques.

The electrical method of control does in fact compare very favourably with the pneumatic, except in one respect. There is as yet no electrical equivalent to the pneumatic diaphragm valve. It is very probable that the success of the pneumatic controller has been due in no small part to the efficiency and simplicity of the diaphragm valve. Until an electrical unit competitive in every way can be produced, there seems no alternative to the obvious choice of the pneumatic valve as the process regulating unit. This means that with the present electrical controller it is necessary to use an electro-pneumatic positioner to operate a conventional pneumatic valve as the final regulating unit. The system is not then completely electrical, a supply of compressed air being still required, and this may possibly be a major disadvantage to the smaller factory where a suitable air supply is not already available.

The electrical three-term controller

The only electrical three-term instrument at present on the British market is that manufactured by Evershed & Vigonoles Ltd. The operating signals used throughout for indicating, recording and controlling are small D.C. currents varying from 0 to 30 mA for the full range of the measured quantity. A special transmitter is required for each variable to be measured, but they all work on the same principle, that of the Evershed electronic repeater. The mechanical torque of the measuring element is opposed by the magnetic couple exerted by the anode current of a triode valve, whose grid bias is varied by any deflection of the measuring system in such a manner as to maintain a continuous force-balance in the system. The electronic unit is generally separated from the transmitter and brought into the control room, being connected by a five-core cable. The operation is entirely independent of line resistance and changes in the mains voltage or frequency. Indicating or recording is accomplished by including in the anode circuit at any convenient point either a milli-ammeter or a known resistance across which a potential drop can be measured potentiometrically.

The schematic circuit of the controller



Fig. 9. Electronic process controller.

is illustrated in Fig. 8. The current I_m , proportional to the measured quantity, is obtained from the electronic unit of the transmitter, which is actually included in the controller, but not shown in the diagram. This current is passed through the indicator 1, and one coil of the double-coil unit 2, a movement of which varies the light distribution on the photo-cells in the grid circuit of the valve 4. Passing through the same coil of the unit 2 but in opposition to I_m is a current I_c proportional to the desired value, and derived from a second electronic repeater unit (not shown) which serves as a current stabiliser. Adjustment of the desired value is by a wire-wound variable resistance in the output of the repeater unit. The resultant current in the first coil of the movement 2 is thus $I_m - I_c$ or I_0 , i.e. proportional to the deviation of the controlled variable.

The photo-cells of the movement 2 control the grid voltage of the valve 4, whose anode current is fed back through the second coil of the movement in opposition to a fixed current from the potential source 5. The resultant current I_p can thus flow in either direction and is arranged to be zero when $I_m = I_c$, so that the current in both coils is zero when there is no deviation. The current I_p also passes through the regulating unit and in the circuit, as so far described, I_p is equal to I_0 and the proportional band will be 100%. By fitting a differential shunt 3 across the two coils of movement 2, the band width can be varied in theory from zero to infinity and in practice from 2 to 600%.

Integral action is derived from the second moving coil unit 6, which is in series with the regulating unit and thus carries the current I_p , proportional to deviation. Deflection of this unit causes an unbalance of the photo-cell bridge unit by changing the light distribution. The unbalance current of the bridge is used to charge the large condenser 10 in the grid-cathode circuit of the valve 12. The voltage developed across a condenser is, of course, the integration of the charging

current with respect to time, and thus the anode current passed by the valve will be $I_i \propto \int I_p dt$ or $\int 0 dt$. This anode current is passed through the regulating unit in the same manner as the proportional current I_p .

The photo-cells are of the vacuum type and above the saturation voltage are insensitive to voltage changes. They thus behave as current sources and the integration rate is independent of the state of the condenser charge. The voltage across the condenser is thus a true integral of the deviation; the integral action time is a measure of the rate of integration and is adjusted by varying the light supply to both photo-cells through the resistance 11.

Derivative action is generated by using the voltage drop across a variable resistance 7 in the proportional current circuit to charge a large condenser 8, through a fixed resistance 9 of 50 megohms. Any change in the current I_p through the resistance 7 will produce a charging current in this loop and hence a voltage drop across the resistance 9, which will be proportional to the rate of change of I_p and thus to the rate of

change of deviation, i.e. $V \propto \frac{dI_p}{dt}$ or $\frac{d\theta}{dt}$

The resistance 9 is also in series with the integral condenser 10 in the grid-cathode circuit of the valve 12, and thus the anode current of the latter will also contain a component proportional to the rate of change of deviation, the proportionality (action time) being controlled by the variable resistance 7. The total current passed to the regulating unit will thus be the sum $I_p + I_i + I_d$, giving the required three control actions.

The controller is illustrated in Fig. 9; in addition to the adjustments for desired value, proportional band, and integral and derivative action times, which are calibrated in appropriate units, a multi-position 'auto-manual-service' switch and a manual control are also provided. A very useful feature of the instrument is the means of ensuring a 'bumpless' transfer from manual to automatic control. This is done by passing the controller output current, when on manual control, through a dummy load, and comparing this output current with the manually-set current to the regulator, by passing the two currents in opposition through a second coil of the movement 6 (not shown in Fig. 8). Any difference between the two currents will cause an extra deflection of the moving coil and a change in the integral component until the two currents are equalised. Thus at all times the controller output current is held equal to the manually-set current feeding the regulator and on changing to automatic control there can be no sudden movement of the regulator. The indicator on the controller displays the controller output current at all times for direct comparison to the scale of the manual control

(Concluded on page 434)

Industrial Electrodialysis Cell

Electrodialysis is the diffusion of electrolytes through a membrane, accelerated by the application of a direct electric current, resulting in the accelerated dialysis or purification of a colloidal solution. This process finds practical application in the desalting of solutions, for example whey, molasses, pepsin, salt water, etc., but until recently has presented a number of difficult problems when operated on an industrial scale. An improved electrodialysis cell for industrial applications was developed by the Dutch Central National Council for Applied Scientific Research as the result of work initiated by Ir Jan Al, the Council's director, during the war. At that time particular importance was being attached to the desalting of crude pepsin solutions in the production of pepsin. This cylindrical electrodialysis cell operates on the same principle as the conventional flat cell and has been built and operated on pilot-plant scale. Below is a technical description giving details of the basic design, materials of construction, inherent advantages, practical difficulties and potential applications.

Electrodialytic desalting

THE problems involved in the desalting of solutions on a commercial scale depend mainly on the character of the solutions. Solutions can be divided into four groups containing as follows:

- (a) inorganic salts (sea water, spring water);
- (b) low-molecular organic matter in true solution, apart from inorganic salts (hydrolysed proteins, sugars);
- (c) colloidal substances, apart from inorganic salts (pectin, sera, ferments, crude pepsin);
- (d) colloidal substances, apart from inorganic salts and low-molecular organic matter in true solution (whey, molasses).

In the latter two groups, distinction is made between aqueous solutions with colloidal impurities, and those intentionally colloidal. For example, molasses contain mainly sugar and salts contaminated with colloidal substances, which form an objectionable impurity in the further processing of the molasses. On the other hand, in whey or casein the colloidal substances (proteins) constitute a valuable component.

In the first case the problem can be solved by removing the colloidal substances in one way or another; in the other case the colloidal substances must be retained unchanged by preventing denaturation as far as possible. In the case of groups (c) and (d) salts may be present as ions or bound by absorption on the colloids and, in this latter case, desalting problems are considerably more difficult. In desalting liquids, it is general practice to remove the salts in such a way that nothing or little of the substances being treated will be lost.

The electrodialysis process is suitable for desalting all four groups of aqueous solutions and it does not introduce as much risk of denaturing colloids as does desalting by ion-exchangers. The possibility of maintaining the pH of the solution within narrow variable limits by the method developed by A. J. Kwak, a member of the Council's research team, has a great advantage, e.g. in the desalting of sugar-containing solutions, since it prevents both inversion of the sugars at low pH values and certain chemical changes at high pH values.

Compared with the conventional dialysis process, electrodialysis is a much more rapid desalting operation, thus also reducing the loss of the dialysate to a minimum. Some losses, due to normal dialysis phenomena, also occur with the electrodialysis process, but these are limited to very small amounts.

General rules cannot be given for the electrodialysis process, since the optimum conditions must be determined for each

single liquid being processed. Until now the electrodialysis process had not been used on an industrial scale, as all former results appeared unsatisfactory. It also presented considerable technical difficulties, for example the corrosion of anodes and membranes. In addition, the high energy consumption per unit of substance at a certain degree of desalting was, until now, a considerable disadvantage.

The electrodialysis desalting process was not previously developed to a degree that warranted its application in chemical technology. On the other hand, it has been widely applied on a laboratory scale in other fields of science, particularly in colloid chemistry and biology.

Problems incurred in investigations

The original purpose of the investigations was to discover a method of producing more rapid dialysis. Acceleration of dialysis by application of electric current was already known. Maintenance of a given pH in the dialysate during operation, however, presented difficulties, while energy consumption was also very considerable.

By changing the composition of the rinsing liquids, Kwak succeeded in maintaining pH values of the dialysate within narrow limits. The results he obtained indicated that the electrodialysis process was of interest for desalting other liquids.

Loss of substances that are an integral part of the product must be limited as far as possible. Losses can be due to (1) precipitation on the membrane, (2) inversion of sugars, denaturing of proteins not due to coagulation and (3) losses through the membrane. The losses mentioned under (1) and (2) are closely connected with the pH value of the dialysate; the losses mentioned under (3) are due to dialysis that always occurs when membranes are used. The quantity lost in this way depends mainly upon the composition of the solutions to be treated, upon the membrane, and so on. The entire problem is complex.

If losses due to dialysis are small, increase in current density is negligible; but with heavy losses, the change in current density has an effect. An increase means higher energy consumption and heat

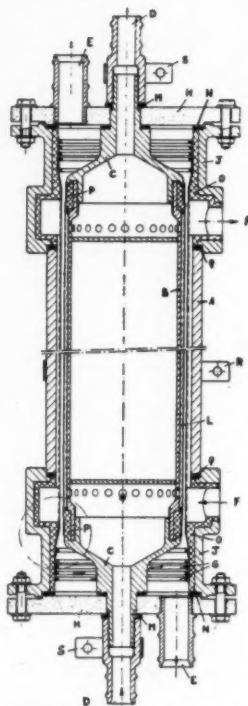


Fig. 1. Improved cylindrical electrodialysis cell. A = Anode. B = Cathode. C = Cathode heads. D = Inlet and outlet for cathode rinsing liquid. E = Inlet and outlet for dialysate. F = Inlet and outlet for anode rinsing liquid. G = Wire springs to fasten anode membrane. H = 'Vinidur' lids. J = Cylindrical steel anode heads with circular inlet or outlet for anode rinsing liquid. L = Supporting gauze for cathode membrane. M, N = Sealing rings. O = Anode rubber lining. P = Cathode rubber lining. Q = Rubber packing. R = Anode terminals. S = Cathode terminals.

generation; both rise in proportion to the square of the current. The increase in heat must be compensated to prevent difficulties in operation, e.g. by heat degradation of proteins in the dialysate compartment.

The cylindrical electro dialysis cell

Investigations into the requirements of electro dialysis apparatus for commercial use led to the development of a cylindrical electro dialysis cell. In principle the construction of a cylindrical cell corresponds with that of the flat cell. Like the latter there are three compartments, bounded and separated by electrodes and membranes. With the cylindrical cell, however, one of the electrodes is the outer wall of the cell. This wall must be rigid enough to fulfil all mechanical requirements. From a practical point of view a magnetite-lined steel anode tube was selected for the outer walls, since an inner magnetite layer turned out to be less porous and more closely adhering to the steel outer wall.

The magnetite layer is formed on the inner surface of a tubular steel anode by means of high-temperature steam. It must have a thickness of at least $\frac{1}{8}$ in. Less thickness would give a layer too porous to prevent the outer steel wall from corrosion by the acid anode rinsing liquid. The steel tube itself has a wall thickness of $\frac{1}{4}$ in. Up till recently these electrodes could only be prepared in lengths of 14 in. each; further practice and experience, however, enabled 3-ft. lengths to be manufactured. Prior to the treatment by which the magnetite is formed, the inner surface of the anode steel tube must be accurately machined on a lathe.

At both ends of the tubular anode, cylindrical steel heads are connected, each provided with a circular inlet or outlet for the anode rinsing liquid. The inner sides of the heads are rubber-lined to shield the metal from corrosion and to facilitate a good closure between the heads and the anode tube. For the latter purpose concentric packing grooves have been cut in the fitting metal parts to prevent the rubber from being pressed out. The anode membrane is fastened to the rubber cover by means of stainless steel wire springs. A *Saran* gauze hose is used to stiffen the membrane as well as to keep it at the desired distance from the anode.

The anode heads are sealed with *Vinidur* lids, each with an inlet or outlet for the dialysate, holding the cathode steel heads. With the aid of the *Vinidur* lids the cathode membrane is also accurately fixed with regard to the anode. The tubular cathode may be seen (Fig. 1) in between the cathode heads, the axes of which coincide with that of the anode tube. The cathode tube has been accurately turned externally, its outer diameter being 18 mm. smaller than the inner diameter of the magnetite-lined anode tube.

The anode tube has also been made of steel, although this is a disadvantage since steel is liable to corrode when the apparatus

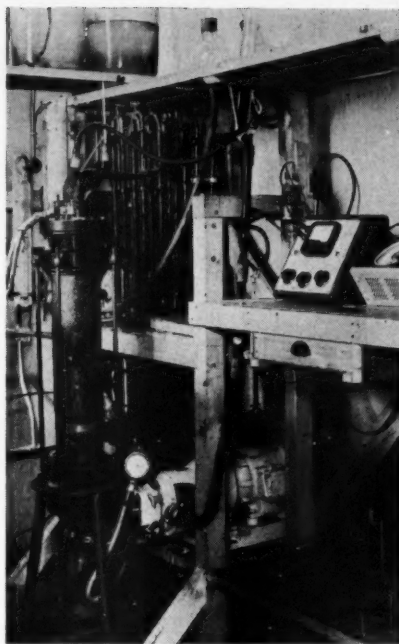


Fig. 2. The experimental electro dialysis apparatus for batch or continuous operation in one desalting stage. It has been used for pilot-plant investigations and has proved suitable for continuous operation. Cooling has only been applied to the dialysate circuit.

is out of use. Iron hydroxide must not be present in the rinsing liquid since it may be precipitated on to the membranes and thus cause a considerable decrease in the mechanical strength of the membranes and other parts of the apparatus. To prevent corrosion, the cathode space is always filled with an alkaline solution as soon as the apparatus is out of use. Although this suffices in the experimental stage, it is advisable to use nickel-plated-steel cathode tubes, which are not attacked by acids, for industrial equipment.

Steel discs have been inserted in the cathode tube and are welded to seal the inside of the tube. The cathode rinsing liquid then flows from the supply connection at the top head and through a ring of holes to the outside of the cathode tube and membrane. The cathode heads to which the membrane is fixed are also rubber lined. The membrane is kept at the correct distance from the steel tube by means of rods fixed between the cathode heads and tube.

The space between the anode and cathode membranes is for the dialysate. Metallic parts in contact with the dialysate are of stainless steel or resin-coated steel. The resin also acts as insulating material.

The dialysate is supplied via the compartment between the cathode heads and the outer cylinder. Appropriate connections are fitted in the *Vinidur* lids. Regular supply of the dialysate is insured by the shape of the compartment. Metal strips and a clamp are attached to the anode and cathode respectively for the electric supply.

Cell dimensions

The apparatus has been designed to comply with commercially available *Cellophane* membrane bags, having a diameter of 4.5 in. and 5.5 in. Since the diameters of the membranes in the cell differ only by 18 mm. the cathode membrane diameter has been adapted to the available bag size, whereas the anode membrane has to be stretched up to the required diameter.

Since the actual distance between the electrodes amounts to only 9 mm., the widths of the dialysate compartment and the rinsing compartment are less than $\frac{1}{4}$ in. each. The length of the electro dialysis cell is determined by the dialysate, particularly by its viscosity, as the pressure required to give the dialysate sufficient speed to traverse the dialysate space, is limited. The *Cellophane* membranes can withstand a maximum pressure of 6 atm. The optimum length of the electrodes must still be determined in practice. The thickness of about $\frac{1}{8}$ in. of the three compartments in the cell appeared to be favourable. Pressures applied to circulate the liquids vary from 0.3 to 0.5 atm. with the treatment of a dialysate having a viscosity value of about 2 cp. With less viscous liquids, smaller space thicknesses are considered, for example in the case of desalting sea or spring water.

Comparison with the flat cell

Electrodes. The cylindrical shape is more rigid than the rectangular or flat form, so that with the former, variations in the distance between cathode and anode do not occur so easily. Production of a smooth and regular surface is much easier with the cylindrical cell, since it can be machined on a lathe. It is also more economical and easier to put a sound magnetite layer on a cylindrical electrode.

Liquid flow and membrane damage. The flat cell is less advantageous than the cylindrical cell from the viewpoint of liquid flow. With the former the long and narrow side-walls adversely affect the regular distribution of flow speed, even when the liquid is supplied regularly. Thus the tension of the membranes becomes irregular and finally results in damage at the rims. With pressure differences at both sides the membranes will always bend outwards to some extent. Such pressure differences are unavoidable in practice.

To fix the membrane it must be pressed against the tubular frame of *Saran* gauze. A symmetric rotational liquid supply dispenses with centring elements in the cell. Since the membrane is uniformly spaced from the electrode along the whole length, the current density along the membrane will also be the same value at any height. That this is not the case in the flat electro dialysis cell may be demonstrated by colouring the anode membrane with methylene blue.

Insulation. In each electro dialysis cell anode and cathode insulation is of great

importance. Contact between the anode and cathode rinsing liquids is practically impossible in the cylindrical cell. Such contact would only be possible through the *Vinidur* lids and the rubber linings.

Apparatus with enlarged membrane surface. The membrane surface of the cylindrical electrodialysis cell can be increased by using a larger number of cells. The application of elongated cells or of cells having a larger diameter appears to be limited. With multiple cells electrical connection in series is appropriate.

Constructional materials

Account must be taken of the liquids in contact with the materials, as well as electro-chemical effects, in the selection of suitable constructional materials for an electrodialysis apparatus. The cathode rinsing liquid is alkaline and is therefore relatively non-corrosive. Thus a considerable number of materials can be used as cathode.

The dialysate presents few difficulties regarding the choice of suitable materials, although the use of special steel or alloys, for example stainless steel, is often advisable. High demands, however, are made upon the constructional materials for parts that come into contact with the anode rinsing liquid. This liquid is acid and may be highly corrosive if special precautions are not taken.

The electrodes. Since the graphite electrodes proved to have some disadvantages, use was made of magnetite electrodes. As magnetite electrodes of the desired dimensions were not available commercially, the investigators specially prepared magnetite-lined steel tube electrodes themselves. Magnetite is considered particularly suitable for chloride electrolysis, since with this little or no acid is generated at the anode.

A large number of various constructional materials are resistant to alkalis. Steel and nickel are both suitable. Steel is the cheaper material, but nickel resists corrosion even when the apparatus is out of use and the use of nickel-plated steel is suggested.

Membranes. An essential part of the electrodialysis apparatus is the membrane. *Cellophane* was selected from various materials that were tried for this purpose, although it tends to deform under wet conditions. The latter disadvantage was overcome by supporting the *Cellophane* bag with a *Saran* gauze hose. The *Cellophane* bag must have a thickness of at least 120 microns. *Saran* gauze proved the best of all the membrane-supporting materials tried. This material, a vinyl chloride and vinylidene chloride fibre, has already been in continuous use for over half a year and is still undamaged.

With the desalting of whey it became apparent that chemical attack on the anode membrane exceeded expectations. This was presumably due to the formation of carboxyl groups in the cellulose. In the

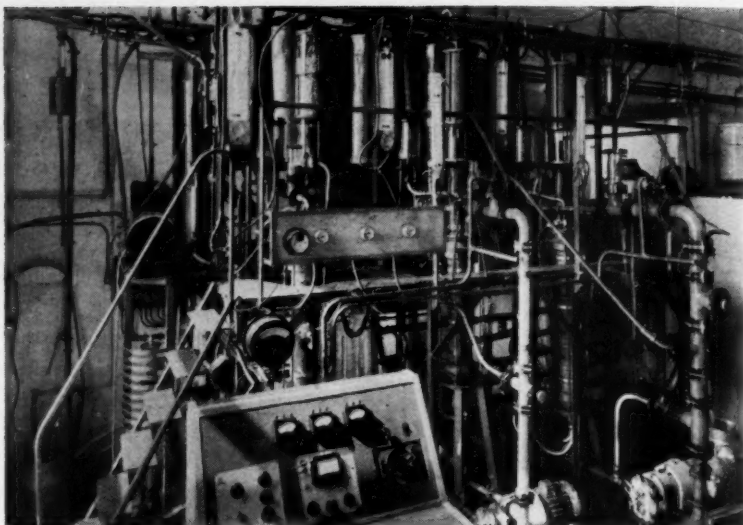


Fig. 3. Electrodialysis cells for continuous desalting of solutions in three stages. In the foreground can be seen the control panel, showing three voltmeters for indicating the voltage at three stages, as well as various switches for pH and resistance measurements. The ammeter is seen immediately above the panel. The tops of the cells pass through the platform. The equipment shown also includes dialysate, rinsing liquid and metering pumps, rinsing liquid containers, de-gassing vessels (two to each stage) and dialysate expansion vessels.

desalting of whey and many other liquids restriction of attack on the membrane is essential to decrease processing costs. During the desalting of water, effective protection of the membrane is a vital condition. This may be accomplished by blowing air through the anode rinsing liquid, in the cell or in a special vat. Thus, aerating the anode rinsing liquid to lower the chlorine concentration seems the most favourable way to prevent membrane corrosion by hypochlorous and related compounds formed in the cell.

Present applications of electrodialysis

In the Netherlands an electrodialysis apparatus has been developed by the investigators for the pilot-plant scale desalting of aqueous solutions, e.g. the desalting of whey. Results of fundamental research in this field have been described in brief in *Food Manufacture*, September 1951, p. 355.

Much attention has been, and still is, paid to the desalting of water, especially in some countries where the drinking-water supply has, or soon will, become a major problem, for example the Netherlands, U.S.A. and some Caribbean isles. In other countries similar considerations apply to irrigation water which could be economically prepared from brackish water.

The waste products, e.g. whey, molasses and stick-water, from many process industries such as dairy plants, sugar mills and fish processing plants contain salt, apart from other, often more valuable, constituents. Isolation of the latter constituents, e.g. proteins from whey and sugar from molasses, may be economically sound; so may the desalting of other effluents. Furthermore, the use of electro-

dialysis for effluent treatment may be instrumental in preventing the increasing pollution of waterways. Various other applications are still under investigation.

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Copper production. In response to many requests from teachers and students, a booklet has been published by the Copper Development Association which explains briefly and simply how commercial copper is derived from the original ore by mining, dressing, smelting, refining and fractionating. Copper ore deposits occur in a wide range of types, several frequently being found even within a single mine; and as each type of deposit presents its own problems of mining and extraction, the methods of treating the ores necessarily differ widely. Nevertheless, there is a general sequence of operations through which most copper ores must pass. Within the limits of this booklet all that can be done is to outline this sequence, it being understood that the details will differ from one plant to another. Available free on application to the Association, this booklet is admirably produced and contains a number of excellent illustrations. A map shows the distribution of copper ores in the principal producing countries of the world.

METALLURGY

Titanium, zirconium and other new metals; chromising; cold extrusion and non-destructive testing

By H. A. Holden, M.Sc., A.R.C.S., D.I.C., A.I.M.

NON-FERROUS

Titanium

TITANIUM and its alloys continue to attract a great deal of research and investigation. Although their industrial application is still very much in its infancy, Church¹ considers that titanium will 'mature' at a much faster rate than either aluminium or magnesium. The aircraft industry is obviously the largest potential user of these materials and possible uses in this sphere have been reviewed.² As titanium is stated to be the only high strength material known for which the stress/cycle curve in a salt water corrosion fatigue test closely approaches that for tests in air, the naval applications merit investigation, and details have been published of the work being undertaken by the U.S. Naval Experiment Station.³

Taylor⁴ tested the acid-resistance of tantalum, niobium, zirconium and titanium and found that tantalum was superior to both zirconium and titanium; however, all were rapidly attacked by hydrofluoric acid. The mechanism and rate of dissolution of titanium in hydrofluoric acid has been studied by Straumanis and Chen,⁵ who suggest that it is probably an electrochemical process based on the activity of local elements. General details have been published on the hot and cold workability of the metal and its alloys.^{6,7} From the point of view of hot working, McPherson and Fontana⁸ have prepared and studied titanium-chromium alloys. They found that alloys containing 0 to 20% Cr were forgeable, the addition of 13 to 18% chromium almost doubled the strength of the titanium, and above 16% chromium the oxidation resistance was greater than that of titanium. The alloys were unsuitable for high temperature stress applications, however, as they had low hot-hardness and poor stress rupture properties. The impact strength of titanium and a chromium base alloy (4 to 6% Cr; 3.1% Al; 0.49% C; 0.022% N) was examined by Pitler and Jaffe⁹ over the range -320°F. to 1,470°F.

On the purely academic side, research has been carried out on the optical emissivity¹⁰ and electrolytic polishing of titanium;¹¹ the effect of the elements of the first long period¹² and the rate of cool-

ing¹³ on the $\alpha=\beta$ transformation; the evaporation of β -titanium between 1,650° and 1,810°K;¹⁴ alloy systems with copper,¹⁵ iron,^{16,17} aluminium,¹⁸ chromium,¹⁹ silicon,²⁰ 0 to 5 at -% oxygen,²¹ molybdenum and niobium;²² alloys prepared by powder metallurgy,²³ and the application of hydrogen equilibrium-pressure measurements to the investigation of titanium alloy systems.²⁴ The stability and chemical reactivity of titanium nitride and carbide have been studied²⁵ whilst a report on the explosibility of titanium, zirconium, thorium and uranium and their hydrides has been published by the U.S. Atomic Energy Commission.²⁶

Zirconium

Although titanium is now so prominent in non-ferrous metallurgy, a great deal of interest is being shown in zirconium and other 'less common' metals. For example, during the past three years the U.S. Atomic Energy Commission has published four reports comprising a total of 88 pages dealing with zirconium alloys^{27,28} and their formation by powder metallurgical methods.^{29,30} In the latter connection, studies of the properties of the sintered metal have shown that zirconium is suitable for fabrication by powder metallurgical methods and that the use of the hydride powder has advantages over the metal powder.³¹

The properties, applications and production in the U.K. of the metal and its alloys have been reviewed by Miller^{32,33,34} and the working of ductile zirconium has been discussed by Hayes, Dilling and Robertson.³⁵ Of the alloys, those with magnesium have very high strength:weight ratios, and they are finding increasing industrial use.³⁶ Sauerwald has reviewed the extrusion and forging properties of these alloys³⁷ and it has been found that alloying additions of small amounts of the rare earth elements simplify their foundry handling; a typical example being EK 30 (2 to 4% rare earths, 0.1 to 0.4% Zr).³⁸ The mechanical and oxidation resistance of binary alloys containing Hf, Ti, Al, Ta, Nb, W, Mo, Cu, O or N have been investigated by Litton.³⁹ Nitrogen and oxygen both improved the ductility, but in general the alloys were found to be less

resistant to oxidation than the commercially pure metal.

Another lengthy U.S. Atomic Energy Commission Report (43 pp.)⁴⁰ deals with preferred orientation in zirconium,⁴¹ whilst other investigators have reported the results of research into the heat capacities and entropies of the metal, its nitride and tetrachloride;⁴² attempts to electrodeposit the metal and its alloys;⁴³ metallography;⁴⁴ permeability to hydrogen;⁴⁵ reaction with hot ionized gases;⁴⁶ and grain growth and recrystallisation properties.⁴⁷

Other less common metals

Some indication of the rapidly widening scope of non-ferrous metallurgy is given by the following very brief details of recent work carried out on molybdenum, beryllium, vanadium and thallium, etc.

A technical note (75 pp.) issued by the U.S. National Advisory Committee on Aeronautics⁴⁸ describes investigations on the tensile properties of high purity, sintered, wrought molybdenum at 980° to 1,315°C. in protective atmospheres. Exceptional tensile, ductility and stress-rupture properties are reported, which are claimed to be comparable or superior to those of temperature-resistant materials now in use. At 980°C. the tensile strength varied between 25,000 and 33,000 lb./sq. in., decreasing to 13,000 to 26,000 lb./sq. in. at 1,315°C. In this country, Corbett has published results on the use of molybdenum for metal spraying⁴⁹ and recommended procedures for cleaning, electropolishing, metallographic polishing and etching the metal are available.⁵⁰

Richards⁵¹ has prepared a comprehensive review of beryllium and its alloys; Hausner and Pinto⁵² have studied the powder metallurgy of beryllium; and the U.S. Atomic Energy Commission has given details of a method for the extrusion of beryllium into rods and tubing.⁵³ The extrusion temperature is 815° to 1,040°C., and the billet is clad in soft iron as a drawing coat. A rod reduced by 98.4% in area gave an ultimate tensile strength of 53,000 lb./sq. in. and an elongation of 0.9%.

Vanadium bearing deposits occur in Colorado, Peru, N. Rhodesia and S.W. Africa and the metal (99.8 to 99.9%) is at present being produced by the Union

Carbide and Carbon Corporation. Their potential of 100 lb./day has, however, not yet been attained.⁵⁴ The metal is claimed to be easily workable with a machinability equivalent to that of cold rolled steel. It may have possibilities as a spring material as it has a good modulus: density ratio and a high resistance to sea water and salt spray.

Other miscellaneous items include a 50-page information circular from the U.S. Bureau of Mines⁵⁵ on the properties, preparation, sources and uses of thallium and its alloys; U.S. Atomic Energy Reports of 79 and 92 pp., respectively, on the rare earths with particular reference to cerium.^{56,57}

Aluminium alloys

The Materials Laboratory, Air Development Force, Wright Patterson Air Force Base, has released information on their new 'ML' aluminium casting alloy,^{58,59} which is designed for use at 260° to 315°C. With a nominal composition of 4% Cu, 2% Ni, 2% Mg, 0.3% Mn, 0.3% Cr, 0.1% Ti and 0.05% V, this alloy is claimed to possess tensile, creep and stress-rupture properties at 315°C. approximately 35% higher than other alloys used for elevated temperature service. The alloy as cast has a U.T.S. of 14.7 tons/sq. in., yield strength of 13.8 tons/sq. in. and 1.2% elongation. At 149° and 316°C. the U.T.S. decreases to 13.0 and 7.6 tons/sq. in. with respective yield strengths of 12.7 and 6.5 tons/sq. in.

In Britain, Cook, Chadwick and Muir⁶⁰ have studied some of the high strength aluminium-zinc-magnesium wrought alloys containing up to 12% Zn, 3.5% Mg and 3% Cu, as well as chromium, manganese, iron and silicon in amounts of less than 1% each, to determine the most satisfactory range of compositions for bulk manufacture. They recommend an alloy containing 6.5% Zn, 1.8% Mg, 1.5% Cu, 0.25% Mn and 0.25% Cr, and the effects of cold work and secondary heat-treatment were also investigated to establish conditions for developing maximum corrosion-resistance compatible with high strength and reasonable ductility. Some German work on the strength of aircraft propellers in aluminium-zinc-magnesium alloys has been published and the results are given of various solution treatments and ageing procedures on the mechanical properties of forged and extruded billets for aluminium alloys containing 2.4 to 3.7% Mg, 4.2 to 5.9% Zn, 0.3 to 0.8% Mn and small amounts of Cu, Si, Fe, V and Ti.⁶¹ T35, a medium-strength alloy (22 tons/sq. in.) containing 2.75 to 3.25% Zn, 1.5 to 1.75% Mg, together with <0.5% of Cr, Mn, Fe and Si, respectively, has now been in production in France for the past three years and is claimed to be very easy to work.⁶² Small additions of chromium, vanadium, manganese and titanium were added to aluminium-6% magnesium alloys in an attempt to improve their properties for

elevated temperature work.⁶³ These increased the tensile strength and creep resistance at 315°C.

Corrosion resistance

A most important paper has been published by Bailey⁶⁴ describing the result of researches carried out over the past 12 years on the development of copper alloys containing 5 to 10% nickel and 1 to 2% iron. These combine the qualities of being both easily worked by the copper-smith and resistant to corrosion by moving sea water. Exhaustive tests were made of resistance to impingement attack in moving sea water containing air bubbles, supplemented by examinations of resistance to attack under deposits in stagnant conditions. The most important results were:

(a) The resistance to corrosion of 70:30 cupro-nickel by moving aerated sea water is greatly increased by 0.3 to 1% iron, but iron contents in excess of this increase the tendency of this alloy for local pitting at areas shielded from oxygen.

(b) If the iron content is below 1%, low nickel content (5 to 10%) alloys are greatly inferior to 70:30 cupro-nickel, but the corrosion resistance of such low nickel alloys is increased by 1.3 to 2% iron additions so that it is of a similar order to that of the 70:30 alloy containing 0.3 to 0.5% iron.

(c) The 5 to 10% nickel/1 to 2% iron alloys offer the optimum resistance to sea water corrosion when quenched from 850° to 950°C. This resistance is reduced, particularly in contaminated waters, by annealing at, or slowly cooling to, 600°C. approximately.

(d) Optimum corrosion-resistance is not compatible with hot workability since heating to 600° to 700°C. during hot working develops a susceptibility for cracking; nevertheless alloys containing 5 to 10% nickel and 1 to 2% iron are easy to cold work and can be hot worked if suitable precautions are taken.

Duranickel,⁶⁵ a nickel alloy containing 4.4% aluminium, together with small quantities of other metals is reported by O'Keefe to have high corrosion-resistance coupled with a strength comparable to that of heat-treated alloy steel.

Miscellaneous

Due to the world shortage of non-ferrous metals, particularly zinc and nickel, the questions of substitutes and 'making do' have received considerable attention, more especially with reference to electroplating. A statement from the British Non-Ferrous Metals Research Association⁶⁶ has recommended that existing standards of coating thickness must remain, but considerable economies can be effected by reducing drag-out losses. Suggestions have also been published for obtaining the maximum use from available nickel anodes and plating salts,⁶⁷ whilst American papers have outlined conditions under which chromate treatments, phosphate, black-oxide and organic coatings are adequate substitutes for electrodeposits.⁶⁸ In a somewhat similar vein, it is interesting to note that although porous iron rotating bands for projectiles manufactured from sintered iron powder were originally developed in Germany during the war to save copper, recent American tests show them to have a superior performance, particularly for high velocity projectiles.⁶⁹

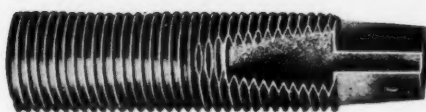
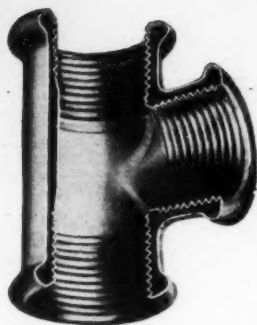
A new coating process attracting considerable attention is that of the vacuum deposition of metals; the most prominent example being that of aluminium as used for reflectors. The principles, methods, applications and disadvantages of this technique have been discussed, as well as its extension to include other metals such as gold, silver and Inconel, etc.^{70,71}

FERROUS

As a bridge between the rapidly-expanding horizons of the 'light' metals and the long-established metallurgy of iron and



Longitudinal section of copper (above) and copper-5% nickel-1% iron alloy tubes after testing for one month in flowing aerated sea-water. [Courtesy: J. Inst. Metals]



[Photos: Diffusion Alloys Ltd.]

Above: Chromium diffused mild steel part.

Left: Section of chromium diffused malleable casting.

By the chromium diffusion process, the chromium penetrates the steel and therefore does not alter the dimensions, even of threaded parts. It is claimed to give an excellent corrosion resistant and hard-wearing surface, comparing favourably with normal stainless steel for resistance to atmospheric and nitric acid corrosion.

details are available of the properties and corrosion resistance of these three types of 'alloy' coating.⁸⁸ Hoar and Croom⁸⁹ have also studied the thermodynamics of volatile metal chlorides in order to elucidate the reactions occurring in chromising, silicising and tanning. The Spanish investigators, Tofaute and Koek⁹⁰ present corrosion-test results for 18/8, 17% chromium steel and three chromised specimens in boiling nitric acid (45%), acetic acid (10%) and a boiling sulphuric-nitric acid mixture.

Cold extrusion

The most revolutionary recent development in the cold forming of steel is undoubtedly the discovery that it can be extruded. Used on a very large scale during the war by the Germans, the potentialities of this technique as perfected in the Neumeyer method are only now being realised in America, and Britain is still further behind in her development work. Hautmann^{91,92} has described the fundamental principles of the Neumeyer technique which is generally employed for the production of hollow, cylindrical forms. As lubricants, electrodeposited zinc or copper or phosphate coatings were employed, the latter proving more satisfactory. With regard to the steel, he recommends a minimum of 0.02% metallic aluminium and a minimum cooling rate through the A_1 -transformation range of 10°C. min. to secure a sufficiently high ageing resistance, ductility and notch toughness for successful cold extrusion. Some details have been released of the manufacture of 105 mm. shells by the Mullins Manufacturing Corporation^{93,94} by this technique. The chief advantages are claimed to be: (a) large savings in steel—up to 40% in this case; (b) reductions in machining operations; (c) use of low-carbon materials—desired properties being produced by cold working; (d) improved surface finish. Other similar processes include the Heinz⁹⁵ and Phoscoat^{96,97} methods. The latter, however, is merely a method of lubrication.

Non-destructive testing

The non-destructive testing of metals has come into considerable prominence within the past year or so, with particular attention being paid to the use of supersonic devices. So important is this particular branch that in 1951 the A.S.T.M. held a symposium on ultrasonic testing. Rüdiger⁹⁸ has reviewed the use of ultrasonics for testing for cracks, laminations, cavities, welding faults, etc., and they are claimed to be suitable for testing steel forgings with a maximum cross section of 25 ft.⁹⁹ as well as for the examination of pipe welds, flash-bulb welds, etc., where radiography has serious limitations.¹⁰⁰ The papers presented at the symposium deal with ultrasonic wave propagation in materials—a guide to theoretical results; inspection, process and manufacturing control of

steel where, strangely enough, development seems to be much more ponderous, it is appropriate in this Atomic/Jet Age to record that the Iron and Steel Institute Special Report, 1951, No. 43, presents the papers given at a symposium on high-temperature steels and alloys for gas turbines. A vast amount of valuable data is given on the behaviour of ferrous and non-ferrous materials under these very exacting conditions and the original papers give detailed information. The subjects covered included accounts of the development of creep-resisting alloys in Great Britain, America and Germany; an outline of the performance and materials required with reference to creep, corrosion-resistance and weldability, with emphasis on the need for a comparatively cheap steel with properties in between present-day best ferritics and cheapest austenitics; nickel-chromium-titanium alloys of the Nimonic 80 type; austenitic R20 and G18B steels; ferritic H40 and H46 steels; the creep strength superiority of the latter; the comparative immunity of cobalt rich G-32 steel to attack by fuel ash containing V_2O_5 ; elevated temperature fatigue and apparatus for hot fatigue testing; chromium-base and cobalt-rich alloys, etc.

Nodular cast iron is still in the news and the editors of *Steel*⁷⁵ requested all licensees under the International Nickel Co.'s patents for magnesium-treated nodular cast iron to comment on their experience with the material. Satisfactory reports were received on the usefulness of the material over a range of components from a 6,500 lb. hammer casting to lawn mower parts; but one producer found that for light sections malleable cast iron gave better results. Lefebure⁷³ has made a detailed study of acid-resisting silicon-irons and reports 12.5 to 20% Si increases corrosion-resistance, while the 18% Si alloys show the maximum electrical resistance and sensitivity to the action of a magnetic field at ordinary temperatures. Under similar conditions the 13% Si alloy exhibits the lowest resistance. The main characteristics of the alloys are great hardness, brittleness and low tensile strength. A new electrographic method⁷⁴ by which iron-silicon solid solutions containing at least 8% Si can be rapidly distinguished, depends upon anodic oxidation followed by treatment with methylene blue.

Further details have been released of Hy-Tuf,⁷⁵ a steel manufactured by the Crucible Steel Co. (U.S.A.) with a typical composition: 0.26% C, 1.26% Mn, 1.37% Si, 1.91% Ni, 0.09% Cr and 0.43% Mo. Tests showed a better notched bar strength, ductility and possibly better low-temperature notched fatigue properties than SAE 4340 steel. Westinghouse Electric Corporation⁷⁶ have published the compositions of two air-hardening mould steels by the exclusive use of which moulds are improved and costs reduced. Brown⁷⁷ considers that the boron steels developed by the American Iron and Steel Institute open up a new era in alloy metallurgy, and discusses at length how they can replace conventional alloy steels for gears, axles, springs, etc. Another application of the rare-earths is the claim that many 'difficult to work' highly-alloyed corrosion and heat-resistant steels can now be made easy to forge and roll by the addition of 'misch metal' to the melt.⁷⁸ Of particular interest to chemical engineers is an excellent review by Luce⁷⁹ covering the use of stainless steels and other ferrous alloys as chemical engineering materials of construction (328 references). The Iron and Steel Institute Special Report, No. 45, deals with a symposium on the corrosion of buried metals held in December 1951. The metals considered include steel, cast iron, copper, aluminium and lead.

Chromising

The production by 'chromising' of a high chromium-content diffusion-layer on ferrous and non-ferrous materials as mentioned in the previous review on metallurgy⁸⁰ is now firmly established. In the U.K. details have been published of the processes operated by Diffusion Alloys Ltd., New Eltham,⁸¹ and the Metal Gas Co. Ltd., a subsidiary of Colvilles Ltd.,⁸² while Galmiche, who was one of the pioneers of the technique in France has described the Onera process^{83,84} which is claimed to produce bright chromised deposits. Galmiche suggests, however, that the brightness can be increased by electrolytic polishing, for which purpose he recommends the Jacquet cold acetic-perchloric acid bath.⁸⁵ He has also reviewed the kinetics and chemistry of chromium transportation and other elements such as aluminium, zirconium and silicon,^{86,87} and

metals by ultrasonics in such processes as powder metallurgy, grain refinement, the acceleration of solidification, alloying, heat-treatment, fatigue testing, electroplating, tinning and the degassing of melts; basic principles in heavy forging, railroad work, the electrical industry and dynamic testing. The method is used extensively, standard equipment that can be used by non-technical personnel being available, but it is clearly not just another device for rejecting material but a valuable aid to a wide variety of manufacturing processes.

McMuster and Schuffert^{101,102} have described Xeroradiography—a rapid, low-cost, all-electric method of obtaining x-ray images in which no films or chemical processing are required.

Due to the ease with which artificial radioactive substances have become available from the Atomic Energy Research Establishment, Harwell, significant new developments have taken place in gamma-radiography, so that radium has been rendered obsolete,¹⁰³ although radon is a useful source in some cases.¹⁰⁴ Radioactive cobalt, tantalum and iridium have already been introduced for industrial purposes and Tenney¹⁰⁵ states that cobalt-60 is a satisfactory source for steel and for materials of higher atomic numbers whilst iridium-192 is suitable for radiographing light metals.

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New standards

Solvents. The British Standards Institution has just issued two further standards in the series for solvents and allied products, isopropyl acetate (B.S. 1834:1952) and 2-ethylhexyl alcohol (2-ethylhexanol) (B.S. 1835:1952). British Standards for these materials were not included in the original series of standards for solvents, but the greatly increased demand for materials of reliable quality for a variety of industrial uses now justifies their inclusion. Both standards cover specific gravity and distillation range and include a limit for acidity and descriptions of sampling and test methods. In addition, B.S. 1834 includes limits for residue on evaporation, water and ester content, and B.S. 1835 includes limits for ash and aldehydes. These standards cost 2s. each, post free.

Sampling and analysis of flue gases. A British Standard, B.S. 1756:1952, has been prepared to guide industrial fuel consumers in selecting a procedure which may be adopted in sampling and analysing flue gases. It covers not only flue gases from steam-raising appliances and heating boilers but also those produced in the manufacture of iron, steel, non-ferrous metals, pottery, refractories, heavy clay ware, food, cement, glass, certain chemicals and coal gas. Among the apparatus described are the Orsat apparatus for deter-

mining carbon dioxide, oxygen and carbon monoxide and the Haldane apparatus for carbon dioxide, oxygen, carbon monoxide, hydrogen and methane. The standard costs 10s. 6d., post free.

Automatic Process Controllers

(Concluded from page 427)

knob. The manual control is completely independent of the rest of the unit; this allows the controller units to be withdrawn for servicing or replaced by spare units.

The schematic diagram of Fig. 8 is, of course, considerably simplified, e.g. the potential sources shown are actually full-wave rectifiers fed from a mains transformer. The entire unit is unaffected by voltage or frequency changes and, since the currents handled are so small, flame-proofing of the equipment is rarely necessary.

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Japan's Alkali Industry

In spite of having no indigenous resources of salt, Japan has created a very considerable alkali industry since 1872 when the first factory, operating the Le Blanc process, was constructed. Based on imported salt, the industry reached its peak of production between 1937 and 1940, but during the war and immediately afterwards output declined substantially. Production is now increasing, although the universal shortage of electricity in Japan is proving a serious handicap. The development of this important industry and its present technological and economic status is described in the following article.*

THE alkali industry, which produces soda ash, caustic soda and various chlorine products from salt as raw material, is one of the basic industries which are absolutely essential to any industrial nation. In Japan, however, the development of this industry has been delayed on account of three unfavourable factors.

First of all, Japan entirely lacks deposits of rock salt, which are found in Europe and America. There are also in Japan very few areas suited for making bay salt. In consequence of this deficiency, all salt for industrial use must be brought in ocean-going vessels from either the Red Sea and the Mediterranean Sea areas or the China coast.

Secondly, Japan experienced at the beginning great difficulty in obtaining equipment and technical know-how essential for the industrialisation of soda manufacture. Under the circumstances, a great deal of time and effort had to be expended in the domestic development and perfection of the ammonia-soda process, more commonly known as the Solvay process.

Thirdly, owing to the domination of the domestic market for a long period by foreign soda companies, especially Brunner Mond & Co. Ltd., of England, belonging to the Solvay combine, under the conditions described above, there was very little opportunity for developing a domestic industry.

Of the three factors cited above, the lack of self-sufficiency in salt resources has been and is still a very unfavourable factor, which probably has hardly any parallel in the industrial countries of the world. However, these disadvantages were gradually overcome by the measures described below, with the result that by about 1940 Japan became one of the leading alkali manufacturing countries of the world.

Le Blanc soda process

As was the case with the history of the development of the alkali industry in the other countries, the Japanese alkali industry originally began with the Le Blanc process. It was in 1872 that the first alkali factory in Japan was built as an adjunct to the Government-operated sulphuric acid factory of the Government's Mint Bureau in Osaka. Although this factory was closed down soon after because of unprofitability of operations, a new Le

Blanc-process factory established in 1881 by the Government's Printing Bureau in Tokyo finally succeeded in commencing actual production, though on a small scale. This was the beginning of the industrial production of soda in Japan.

Both of these Government-operated alkali factories were transferred to private hands several years after. In addition, two or three more alkali factories were constructed by private companies and by 1890 several alkali companies using the Le Blanc process were in operation. However, since their facilities were very inferior to those of Western countries and since their products were unable to compete with cheap imported products as well as with domestic products manufactured by the Solvay and electrolytic processes, all of them went out of business by about 1917. This fate of Japanese alkali factories using the Le Blanc process was similar to that of the factories of other countries using the same process, except that there was a time lag of 40 to 50 years in the case of Japan.

Ammonia-soda process

This process for the manufacture of soda ash was invented after the Le Blanc soda process and began to be widely used in Europe by about 1870, about which time the first Le Blanc-process factory in Japan was constructed. Owing to the unfavourable factors for the domestic production of soda, however, Japan continued for a long time thereafter to depend on foreign sources for the greater part of its soda ash requirements.

With the stoppage of soda imports from Britain, the principal supplier, on the outbreak of World War 1, the Asahi Glass Co. Ltd., the largest consumer of soda ash in Japan, took the opportunity to build at Makiyama, Fukuoka Prefecture, its own soda manufacturing plant with a daily capacity of 10 metric tons by the ammonia-soda process. This was in 1916, but actual operations were not begun until the following year. Then in 1918 the Nippon Soda Industry Co. Ltd. (later known as the Tokuyama Soda Co. Ltd., but different from the present Nippon Soda Co. Ltd.) built a similar factory at Tokuyama, Yamaguchi Prefecture, for the purpose of manufacturing soda for sale to others, instead of for its own consumption. Thus two factories using the ammonia-soda process came into existence in Japan during World War 1.

However, since their scale of production was not large enough to fill the entire

domestic requirements, a considerable amount of soda products continued to be imported from abroad, chiefly from the U.S.A.

With the end of the war, imports of soda products from abroad began to increase sharply and Japan became the scene of stiff competition between Brunner Mond & Co. Ltd. and Magadi Co. Ltd., both of England, in soda ash, and between the Allied Chemical & Dye Co. Ltd. (which entered the Japanese market during the war) and Brunner Mond & Co. Ltd. in caustic soda. The result was that the domestic soda ash manufacturing industry was immediately confronted with the imminent danger of collapse, which, however, was prevented by raising to some extent the tariff duties after 1921 and by granting Government subsidies for some time after 1929 in view of the need from a national standpoint of fostering the development of the alkali industry.

It was not until 1931 that this industry got out of difficulties and was favoured with a grand opportunity to effect a spectacular development. This opportunity presented itself in the following ways:

With the outbreak in September 1931 of the Manchurian Incident, Japan enforced an export embargo on gold and the resulting depreciation of yen exchange had the following effects on Japan's foreign trade: (1) The rise in the prices of imported goods rendered the prices of domestic goods comparatively cheap, thereby reducing the volume of imports on the one hand and expanding the market for domestic goods on the other; (2) the brisk activity of Japanese export industries stimulated by the lower export prices of Japanese goods in terms of foreign currencies caused an increase in the consumption of soda by the glass, rayon and other manufacturing industries, thereby increasing the domestic demand for soda products; and (3) the expansion of the Japanese merchant marine resulted in a reduction in the freight on imported salt.

Under such circumstances, the two existing soda companies were able to realise satisfactory earnings and to improve and expand their facilities year by year. By about 1934 they were able to operate at 93% of capacity. After 1935 five factories using the ammonia-soda process were constructed respectively by Toyo Soda Industry Co. Ltd. (Yamaguchi Prefecture), Kyushu Soda Co. Ltd. (Fukuoka Prefecture), Ube Soda Industry Co. Ltd.

* Reproduced from 'Survey of Japanese Finance and Industry,' 1951, 3 (9), pp. 1-8, published by the Industrial Bank of Japan, Ltd.

(Yamaguchi Prefecture), Kawanami Industry Co. Ltd. (Saga Prefecture) and Dai Nippon Artificial Fertiliser Co. Ltd. (Yamaguchi Prefecture), which last company is now known as Nissan Chemical Industry Co. Ltd. As a result, a total of seven factories using the ammonia-soda process were in operation by 1937.

These factories were, moreover, able to maintain in 1938 or thereabouts an average operating rate of over 80 per cent. of capacity, producing in that year an aggregate of 660,000 metric tons of total ash, a record up to that time.

Despite this advancement whereby the Japanese alkali industry succeeded in securing a market, there still remained the weakness of being entirely dependent on foreign sources for the supply of salt. When it became difficult to obtain salt from the Mediterranean basin on account of the war situation in Europe after 1936, Japan turned to China for the supply of crude salt. But the supply from this source became increasingly difficult following the expansion of the Sino-Japanese conflict and especially after the outbreak of the Pacific war in 1941, owing to the heavy loss of bottoms. The result was that factories using the ammonia-soda process involving a large-scale production were confronted with serious operational difficulties.

To cope with the situation, the three factories operated by Kawanami Industry Co. Ltd., Kyushu Soda Co. Ltd. and Dai Nippon Artificial Fertiliser Co. Ltd., respectively, either converted their equipment to the production of some other products or entirely suspended their operations. The remaining four factories also converted part of their equipment to the production of alumina and magnesium chloride to meet the urgent war-time demand for these products. As the allotment of crude salt for civil requirements was reduced to less than one-half, they were obliged to lower their operating rate until it was only 10% by the time of the termination of war.

In the immediate post-war period alkali production by the ammonia-soda process was limited to three companies, namely Asahi Glass Co. Ltd., Tokuyama Soda Co. Ltd. and Ube Soda Industry Co. Ltd., in view of the inadequate import of crude salt, the designation of factories as reparations factories (the Toyo Soda Industry Co. Ltd.'s factory was designated as such and suspended operations from December 1946 onward) and the decrease in the demand for alkali products. Between 1948 and 1949 it was planned to suspend the operation of another factory among the three factories in operation until then in order to effect rationalisation of the industry through concentrated production. However, with the subsequent favourable turn in the importation of crude salt and the general industrial recovery of Japan, the projected suspension was abandoned and, by 1950, the industry had recovered

Table 1. Changes in Japan's Soda Manufacturing Capacity, 1930-50 (metric tons)

Year	Ammonia-soda process				Electrolytic-soda process	
	No. of factories	Total ash	Soda ash	Caustic soda	No. of factories	Caustic soda
1930 ..	2	84,600	64,800	7,200	10	24,932
1931 ..	2	131,400	108,000	18,000	11	36,953
1932 ..	2	183,600	126,000	28,800	11	40,298
1933 ..	2	270,000	198,000	108,000	13	51,364
1934 ..	2	360,000	270,000	144,000	16	71,303
1935 ..	4	475,200	270,000	191,520	21	95,571
1936 ..	6	568,800	367,200	267,120	24	141,308
1937 ..	7	716,400	399,600	339,120	24	179,712
1938 ..	7	813,600	457,200	396,520	25	204,966
1939 ..	7	928,800	457,200	414,520	30	216,988
1940 ..	7	928,800	486,000	414,520	30	222,608
1941 ..	4	835,200	403,200	403,200	32	234,958
1942 ..	4	835,200	403,200	403,200	33	234,424
1943 ..	4	835,200	403,200	403,200	35	237,079
1944 ..	4	835,200	403,200	403,200	35	234,468
1945 ..	4	835,200	403,200	403,200	36	253,290
1946 ..	4	835,200	403,200	403,200	36	253,290
1947 ..	4	835,200	403,200	403,200	36	253,290
1948 ..	4	835,200	403,200	403,200	36	253,290
1949 ..	4	835,200	403,200	403,200	36	253,290
1950 ..	4	835,200	403,200	403,200	36	253,290

Sources: Data submitted to the Strike Mission for figures up to 1945; data collected by the Japan Soda Industry Assn. for figures since 1945 for the electrolytic-soda process factories.

to the extent of even resuming, with SCAP permission, the operation of the factory of Toyo Soda Industry Co. Ltd. Recently the industry has become so active to meet the production requirements of the Korean war that an increase in the import of crude salt is being strongly urged. It must be pointed out, however, that great efforts are needed to replace superannuated equipment resulting from neglect during the past 10 years.

Electrolytic-soda process

A study of the history of the development of the alkali industry of the world shows that the industrial production of soda by the electrolytic process began to develop from about 1890, that is, about 20 years after the inception of the ammonia-soda process. In Japan both of these processes were adopted almost simultaneously during World War I, in view of the great difficulties experienced in obtaining the supply of soda from abroad. In the light of the difficulty experienced in mastering the technique of the ammonia-soda process, it may be said that as a whole the electrolytic-soda process was perfected earlier than the former process.

The production of soda by the electrolytic process was first begun in 1915 when the Hodogaya Soda Industry Co. Ltd. constructed in Kanagawa Prefecture a factory using the diaphragm process. This was followed in the same year by the construction in Fukuoka Prefecture of a factory using the mercury process by the Osaka Soda Co. Ltd. Within only two or three years after, that is during World War I, some 16 companies with a total monthly capacity of about 1,000 metric tons commenced production by the electrolytic-soda process. Favoured by a brisk demand for soda products against their short supply owing to import difficulties, all of these companies were able to earn

substantial profits immediately after commencement of operations.

With the end of the war, however, they suffered a severe blow from the business conditions already described under the ammonia-soda process, with the result that only ten of them were able to continue operations thereafter. Since the production of chlorine by-products greatly exceeded the domestic demand, a voluntary production curtailment (average of 50%) was enforced in order to avoid cut-throat competition among the producers.

As in the case of the companies using the ammonia-soda process, those using the electrolytic-soda process witnessed a favourable turn in their business operations after 1932, stimulated by the same factors. However, a significant change affecting the electrolytic-soda process alone was the achievement of a technical solution for the treatment of chlorine. Whereas up to that time the use of chlorine was limited to bleaching powder, its uses were expanded further by the perfection of technique for the manufacture of synthetic hydrochloric acid and liquid chlorine, as a result of which the technical limitations obstructing the development of the electrolytic-soda process were gradually removed. By 1937 the previous trend toward an excess supply of chlorine had been reversed to a shortage of chlorine, as had been the case abroad where this process had been adopted much earlier.

Under these favourable conditions, the operating rate of Japanese alkali manufacturing companies using this process steadily rose after 1930 to 70 to 80% of capacity. Expansion of existing factories, rehabilitation of closed-down factories and construction of new factories were undertaken one after another, with the result that by the peak years 1938-39 the factories numbered more than 30. In addition, a number of soda factories were constructed

Table 2. Japanese Companies Manufacturing Soda by the Ammonia-Soda Process

Name	Date established	Capital stock (Y million)	Name of soda factory	Daily operable capacity (metric tons)	Output in June 1951 (metric tons)	Share price per Y50 share (June 1951 average)	Latest dividend rate	Main products other than ammonia-soda
Asahi Glass Co., Ltd. . .	1907	Y500	Makiyama	550	14,203 (33.9%)	Y246	48	Sheet glass
Tokuyama Soda Co., Ltd. . .	1918	100	Tokuyama	300	9,123 (21.7%)	79	30	Cement
Toyo Soda Industry Co., Ltd.	1935	120	Tomita	315	9,213 (22.0%)	88	30	Electrolytic-soda and chlorides
Ube Soda Industry Co., Ltd.	1936	125	Ube	250*	9,405 (22.4%)	78	30	
Total		845	4 factories	1,415	42,124 (100.0%)			

* The actual operable capacity is believed to be 300 metric tons.

Sources : The Tokyo Securities Exchange for the share quotations and dividend rates ; The Chemical Bureau, Ministry of International Trade & Industry for operable capacity and actual output.

in Formosa, Korea and Manchuria with Japanese capital. The output of caustic soda in 1939 was 145,000 metric tons, a record up to that time.

With the subsequent expansion of the Sino-Japanese conflict, the operating rate of factories using the electrolytic-soda process was steadily lowered as in the case of factories using the ammonia-soda process, owing to the short supply of crude salt and the curtailment of soda shipments to non-essential industries. After the outbreak of the Pacific war in 1941, a considerable number of the factories were liquidated, though, generally speaking, factories using the electrolytic-soda process were preferentially treated over those

using the ammonia-soda process, because of the more efficient use of crude salt by the former process and also the production therefrom of chlorine products essential for war purposes. In any case, at the time of the termination of war the operating rate of factories using either of these two processes had fallen to about 10% of capacity.

The post-war situation of the factories using the electrolytic-soda process has been the same as that of factories using the ammonia-soda process. At the present time 20 factories (including two incomplete factories) remain designated for reparations and the outcome of such designation is looked upon with serious concern as having

an important bearing upon related industries. Since all of these factories, despite their designated status, are at present continuing operations under permission from SCAP, no direct inconvenience is felt in meeting the domestic demand.

Distribution of factories

Generally speaking, the alkali industry requires 4 to 8 metric tons of raw material and fuel for every ton of finished product. Especially in the case of the ammonia-soda process which involves mass production, 600 to 800 metric tons of raw material and fuel must be transported daily to keep a factory working even at its lowest operating rate with the existing equipment. The

Table 3. Japanese Manufacturers of Soda by the Electrolytic-Soda Process

Name	Date established	Capital stock (Y1 million)	Name of soda factory	Annual operable capacity (metric tons)	Share price per Y50 share (June 1951 average)	Latest dividend rate	Main products other than caustic soda and chlorides
Ajinomoto Co. Inc.	1925	Y500	Kawasaki	7,200	Y127	25	Glutamic acid soda and soybean products
Asahi Kasei Co., Ltd.	1931	700	Nobeoka	5,837	139	40	Rayon and explosives
Asahi Denka Co., Ltd.	1917	200	Ohisa	12,707	89	30	Oils and fats
Hodogaya Chemical Industry Co., Ltd.	1916	121	Koriyama	5,521	50	deferred	Dyestuffs and pharmaceuticals
Kureha Chemical Industry Co., Ltd.	1944	100	Hodogaya	8,573	59	15	Superphosphate of lime
Mitsui Chemical Industry Co., Ltd. . .	1941	800	Nishiki	7,211	43	deferred	Dyestuffs, pharmaceuticals and coke
Nippon Chemical Industries, Ltd. . .	1934	250	Miike	4,195	88	deferred	Coke and ammonium sulphate
Nippon Soda Co., Ltd.	1920	580	Yodogawa	22,010	56	15	Ethylene glycol and zinc
Nissin Chemical Industries, Ltd. . .	1925	1,000	Kurosaki	1,849	60	15	Ammonium sulphate, dyestuffs and aluminum
Nissan Chemical Industry Co., Ltd.	1921	500	Nihongi	7,989	58	15	Superphosphate of lime and ammonium sulphate
Osaka Soda Co., Ltd.	1915	75	Takaoka	16,537	*	**	
Showa Denko Co. Ltd.	1939	550	Okayama	5,205	51	20	Ammonium sulphate, calcium cyanamide and aluminum
Tekkosha, Ltd.	1928	360	Niihama	3,648	77	30	Steel alloys and calcium cyanamide
Toa Gosei Chemical Industry Co., Ltd.	1933	300	Fushiki	22,022	80	30	Ammonium sulphate
Toyo Soda Industry Co., Ltd. . .	1935	120	Nagoya	4,742	88	30	Soda ash (see Table 2)
Total for 24 companies (including others not listed here)			36 factories	176,078			

* Not listed on the stock exchanges.

** Unknown.

Sources : The Tokyo Securities Exchange for share quotations and dividend rates ; The Chemical Bureau, Ministry of International Trade & Industry for operable capacity.

weight of the finished products also is quite heavy and thus require mass transportation. Under these conditions, it is essential in the case of the alkali industry that the factories be located near both the raw material sources and the product consuming centres. As the crude salt must be transported a long distance from abroad, practically all of the soda factories in Japan are located on the coast. The four factories using the ammonia-soda process are concentrated in Fukuoka Prefecture (northern part of Kyushu) and Yamaguchi Prefecture (western-most prefecture of Honshu) because these two areas (1) lie near the coalfields in Japan the coalfields are located in Hokkaido, Kyushu, Joban in Ibaraki Prefecture and Ube in Yamaguchi Prefecture), (2) stand nearest to the foreign sources of crude salt and (3) possess large deposits of limestone. On the other hand, factories using the electrolytic-soda process are distributed throughout the country from Hokkaido in the north to Kyushu in the south in consideration of the fact that construction of factories in the interior, though advantageous from the standpoint of proximity to hydro-electric power resources, would be disadvantageous in all other respects, including the difficulty of transporting the by-products (chlorine products) to cities, which are mostly located on the coast.

Productive capacity

The recent changes in the productive capacities of Japanese soda factories using either the ammonia-soda process or the electrolytic-soda process are shown in Table 1.

The aggregate capacity of factories using the ammonia-soda process varies according to the increase or decrease in the number of such factories, in view of the fact that technically the capacity of each factory is fixed at the time of drawing up the blueprint and no subsequent change is possible. For this reason the aggregate capacity of the four companies using this process has remained constant at 835,000 metric tons (calculated in terms of total ash) since 1941.

On the other hand, the capacity of factories using the electrolytic-soda process can be expanded from their original capacity by increasing the number of electrolytic cells, as the occasion demands. For this reason their total capacity could be and was steadily increased year after year until the termination of the last war in order to meet the increased demand for caustic soda and especially chlorides. Another factor responsible for this increase in capacity was the stiff competition in this category because of the imperfect voluntary control in this line of business, with the result that the expansion of capacity tended to constantly exceed the actual demand.

If the theoretical capacity of these two types of soda factories is revised by taking due account of the obsolescence and lack of standardisation in their equipment, etc.,

Table 4. Demand and Supply of Soda Ash in Japan, 1930-50 (metric tons)

Year	Output	Export	Import			Net domestic consumption
			Soda ash	Natural soda	Total	
1930	57,233	0	36,593	28,613	65,206	122,439
1931	77,805	0	18,690	35,642	54,332	132,137
1932	84,204	0	25,918	20,507	46,425	130,629
1933	110,239	0	21,707	24,737	46,444	156,683
1934	132,852	15,401	16,486	20,653	37,139	154,592
1935	197,327	30,521	27,208	21,056	38,264	205,070
1936	244,500	27,400	17,858	22,959	40,817	257,917
1937	245,227	12,292	29,980	17,281	47,267	280,202
1938	250,670	5,052	19,411	2,009	21,450	267,068
1939	253,995	1,487	19,228	0	19,228	271,736
1940	230,944	1,162	16,957	0	16,957	246,739
1941	177,681	948	9,868	0	9,868	186,601
1942	140,149	89	4,909	0	4,909	144,969
1943	145,039	474	2,874	0	2,874	147,439
1944	100,599	263	0	0	0	100,336
1945	46,826	0	0	0	0	46,826
1946	22,350	0	0	0	0	22,350
1947	38,083	0	0	0	0	38,083
1948	75,111	0	0	0	0	75,111
1949	123,806	0	0	0	0	123,807
1950	166,907	3,446*	0	10,000	10,000	173,461

* Includes special procurement export. Source: Survey by the Japan Soda Industry Assn.

Table 5. Demand and Supply of Caustic Soda in Japan, 1930-50 (metric tons)

Year	Output			Export	Import	Net domestic consumption
	Electrolytic process	Ammonia process	Total			
1930	26,539	8,199	34,738	18	37,589	72,309
1931	30,992	17,544	48,536	11	41,596	90,121
1932	37,301	37,815	75,116	2,511	28,193	100,798
1933	47,444	63,509	110,953	5,116	12,447	118,284
1934	64,519	113,252	177,771	12,282	9,928	175,417
1935	92,015	141,273	233,288	17,497	19,936	235,727
1936	116,132	168,867	284,999	23,430	11,597	273,166
1937	131,155	221,876	353,031	5,514	27,429	374,946
1938	145,487	301,671	447,158	11,615	266	435,809
1939	172,060	284,939	456,999	24,279	0	432,720
1940	140,906	265,603	406,509	13,135	0	393,374
1941	129,569	204,379	333,948	7,681	0	326,267
1942	112,568	115,027	227,595	3,390	0	224,205
1943	114,976	110,740	225,716	7,606	0	218,110
1944	100,372	56,774	157,146	470	0	156,676
1945	42,247	14,577	56,824	24	0	56,800
1946	21,514	7,784	29,298	0	0	29,298
1947	35,846	7,306	43,152	0	0	43,152
1948	59,668	48,380	108,048	15,000	0	93,048
1949	90,190	60,130	150,320	0	0	149,879
1950	123,124	77,583	200,707	367*	0	200,341

* Includes special procurement export. Source: Survey by the Japan Soda Industry Assn.

their present operable capacity is reduced to figures shown in Tables 2 and 3.

The total operable daily capacity of the factories using the ammonia-soda process is 1,415 metric tons, being about 60% of the theoretical capacity of 2,320 metric tons, which fact is clearly indicative of the substantial deterioration of the equipment due to overwork during war-time and neglected repair in the post-war period.

In the case of the electrolytic factories, the present total operable annual capacity is 176,000 metric tons, against their theoretical capacity of 253,000 metric tons. Since this is about 70% of the theoretical capacity, their present condition is slightly better than that of the ammonia-soda process factories.

Raw materials supply

Crude salt used as raw material is imported wholly from abroad. In the pre-war period it was imported sometimes

from nearby areas, chiefly China, and at other times from Mediterranean and Red Sea sources, depending upon the international situation. At present, salt is imported from the U.S.A. and Mexico, because of the suspension of trade with Communist China. Since, under such circumstances, the cost of imported salt is relatively high, there is a strong demand for the resumption of trade with China and the expansion of Japanese bottoms with a view to reducing the freight charges.

The sale of salt in Japan is under Government monopoly and in the post-war period a special price lower than the import cost was quoted for salt released to industrial users. Whereas the highest c.i.f. price of salt in the post-war period was \$20 per metric ton (the lowest was about \$8 in 1950), the delivery price to soda factories was quoted uniformly at the official price of 3,000 yen (\$8.33). The loss was covered partly by the higher price charged for table

Table 6. Japan's Consumption of Soda Ash in Percentages by Uses, Selected Fiscal Years 1941-50

Use	1941	1942	1943	1944	1945	1948	1949	1950
	%	%	%	%	%	%	%	%
Light metals	5.8	7.5	11.0	33.3	26.3	2.0	1.0	0.1
Pulp and paper	1.3	0.6	0.4	0.1	0.2	0.5	1.1	1.0
Seasonings	4.7	3.2	8.0	4.1	7.7	10.1	12.7	19.6
Glass	33.4	30.2	20.6	10.2	11.8	33.2	34.7	38.5
Chemicals	28.0	20.8	18.6	13.5	19.0	32.9	37.0	29.6
Textiles	2.4	1.0	0.7	0.2	0.3	2.8	3.2	2.8
Export	0.2	0.2	0.2	0	0	0	0.1	2.1
Munitions	8.0	22.2	28.4	21.0	14.0	0	0	0
Others	16.2	14.3	12.1	17.6	20.7	18.5	10.2	6.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Japanese Soda Industry Assn.

Table 7. Japan's Consumption of Caustic Soda in Percentages by Uses, Selected Fiscal Years 1941-50

Use	1941	1942	1943	1944	1945	1948	1949	1950
	%	%	%	%	%	%	%	%
Light metals	8.9	11.3	23.7	23.0	7.8	5.0	2.6	1.3
Pulp and paper	7.0	4.5	3.6	1.6	3.3	5.4	10.2	14.2
Seasonings	1.8	2.7	0.8	0.5	1.0	1.8	3.1	1.9
Chemicals	16.5	14.2	15.3	16.4	13.4	21.4	25.1	22.7
Textiles*	45.7	36.7	24.1	13.6	18.5	31.6	49.1	53.4
Export	1.6	2.1	2.9	0.6	0	14.8	0.1	0.2
Munitions	6.3	17.7	22.4	31.2	22.7	0	0	0
Others	12.2	10.8	7.2	13.1	33.3	20.0	9.8	6.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Mostly chemical fibre textiles. Source: Japan Soda Industry Assn.

salt and partly by appropriation from the budget. However, this system has been changed since April 1951 and the official price raised to 8,000 yen (\$22.22) per metric ton. As there is now very little difference between this delivery price and the actual import cost of salt, some of the soda manufacturers would prefer to import industrial salt on their own account, and it is believed that this system is likely to be adopted sooner or later.

The domestic supply of coal, other than heavy coking coal for steel manufacturing, is sufficient to cover present requirements (present annual output is 45,000,000 metric tons). The cost of coal (about \$15 per metric ton for factory delivery), however, is considerably higher than in the U.S.A.

Owing to the concentrated demand for electricity in the post-war period because of the high cost of coal as fuel and also to the delay in developing electric power resources during and after the war, there is now a great shortage of electric power. An adequate supply of electric power is a prerequisite for the operation of factories using the electrolytic-soda process. In any case, however, the rise in the cost of electricity has been relatively small under the inflation so that even with the approximately 30% increase in August 1951 the cost of electricity is still lower than that of other forms of energy.

Demand and supply of products

Whereas until 1930 one-half of the domestic demand for alkali products was covered by imports, the latter steadily declined as domestic production increased, with the result that it was possible to export.

A noteworthy increase in the domestic

demand for soda products took place after 1935 in line with the general development of Japanese industries, particularly the glass industry requiring soda ash and the synthetic fibre (rayon and staple fibre) industries requiring caustic soda. During the war, however, the munitions industries, especially the light metal industry, replaced the above two industries as the chief consumer of soda products.

With the post-war recovery of the glass and synthetic fibre industries, the consumption of soda products is steadily returning to the pre-war pattern. Against the estimated annual volumes of 264,000 metric tons of soda ash and 356,000 metric tons of caustic soda desired by the related industries, the Economic Stabilisation Board has estimated their demand in the current fiscal year at 220,000 metric tons for the former and 300,000 metric tons for the latter. On the basis of this estimated demand, the various companies have drawn up their production schedules accordingly. Since there are hardly any impeding factors, with the possible exception of limited availability of electric power for allocation to this industry, production is being carried out according to schedule.

There is, however, a possibility that, depending upon the outcome of the Korean war and the future development of the international situation, production may not work out according to schedule, especially with respect to caustic soda, as there are now indications that the synthetic fibre industry, a large consumer of caustic soda, will enforce 20 to 30% curtailment of operation in view of the recent slump in textile exports and the consequent drop in the prices of textiles.

Prices of products

As stated, the price of salt in other countries is very low. In England and the United States where salt factories are built above the strata of rock salt, the cost of producing salt is limited to the cost of pumping up brine from the underground.

In Japan, on the other hand, the price of salt is very high because it must be transported by ships from remote areas. This fact necessarily makes the cost of Japanese soda products relatively high. Such being the case, under normal conditions foreign products are comparatively cheap and thereby tend to oppress the domestic alkali industry.

Since the import of foreign soda products, with the exception of some Magadi ash, has been checked in the post-war period by foreign trade control, the question of competition with foreign products has been avoided so far. However, now that the post-war subsidy on soda products has been abolished (since October 1950) and the official price system also has been abolished (since April 1951), the relatively high prices of Japanese soda products may again become an important problem to the related industries.

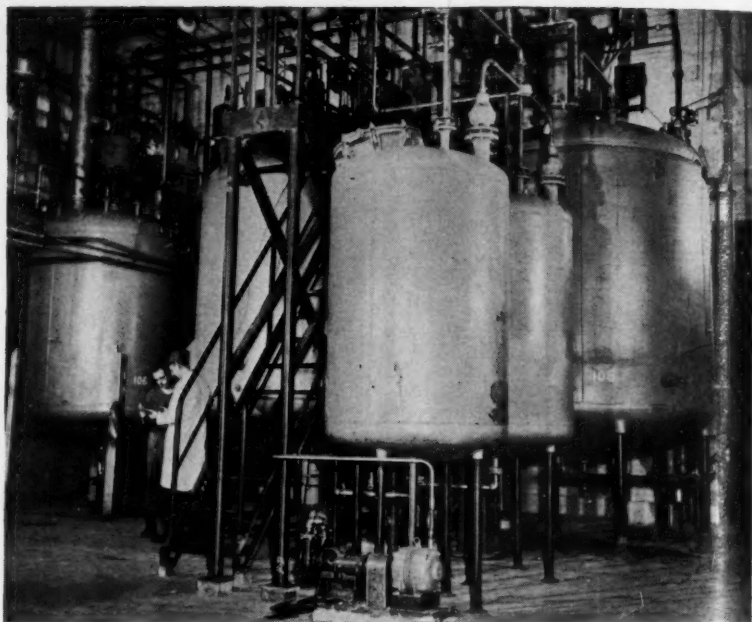
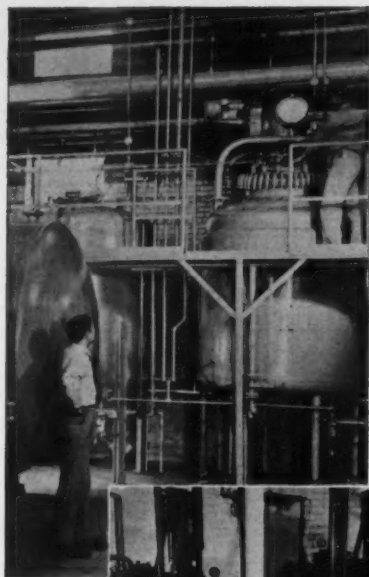
The current domestic price of soda ash is \$95 to \$100 per metric ton and that of caustic soda (95% solid) \$185 to \$190. Though these prices are not so high when compared with the international prices prevailing in the Far East where the supply-demand relationship has become stringent since the outbreak of the Korean war, they are substantially high when compared with prices in England and the U.S.A.

In some quarters the view is held that the domestic prices which have soared since the Korean war will decline if the synthetic fibre industry curtails its operations. The market for soda products, especially for caustic soda, is easily influenced by the movement of this industry, which is the largest soda consumer in Japan. Reports have it that the electrolytic-soda process factories are already curtailing operations, as was done in the pre-war period. Such curtailment, however, is not easily possible in view of the provisions of the Anti-Monopoly Law and the Trade Association Law.

Contributions

THE EDITOR welcomes practical articles and notes on chemical engineering and industrial chemical subjects with a view to publication. All contributions, which should be fully illustrated whenever possible, are carefully considered. A preliminary letter or synopsis is advisable. Address such material to THE EDITOR, CHEMICAL & PROCESS ENGINEERING, 17 Stratford Place, London, W.1.

New 'Chloromycetin' Factory



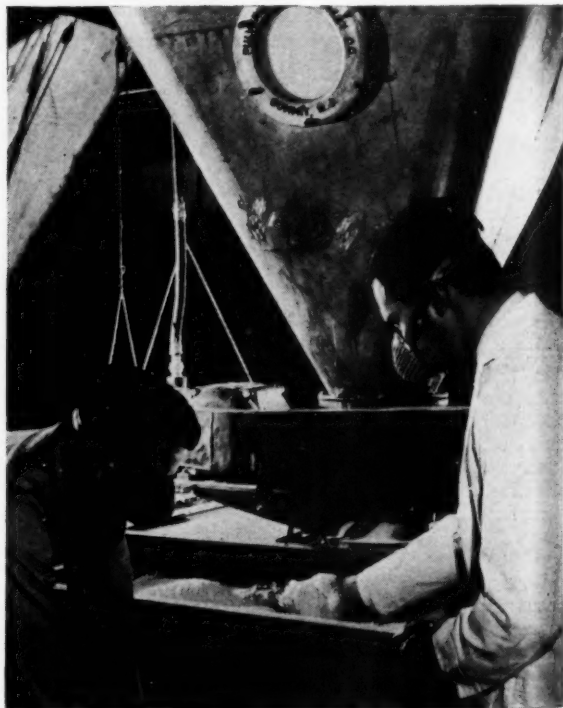
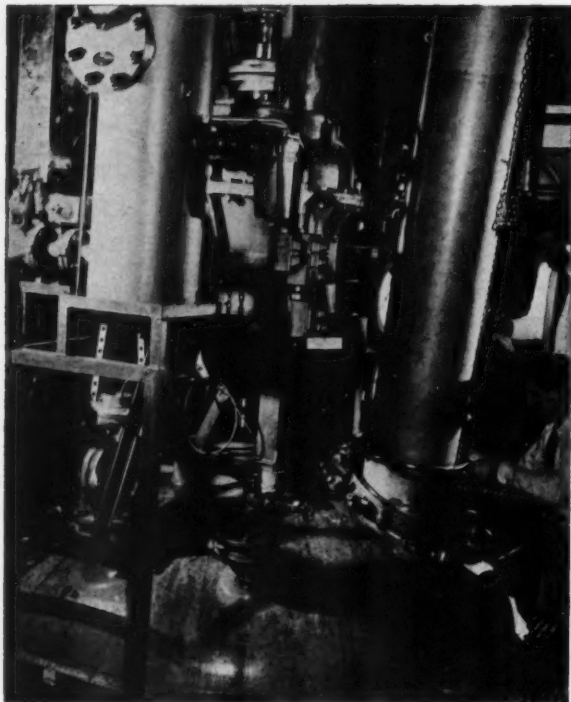
Above: The storage tanks and vacuum stills used in the large-scale synthesis of the antibiotic 'Chloromycetin,' at the new U.S. factory.

Top left: View of the plant showing the controls above one of the stills and the ends of the storage tanks on the left.

Left: Refrigeration and ice-making equipment, showing compressors for cooling water in the foreground, with ice-making equipment behind.

Bottom left: The initial reactor tanks are three stories high. Flaked ice comes from a machine above the tanks and the plant uses 18,000 lb., hr., in addition to thousands of gallons of cooling water.

Bottom right: A control chemist and operator inspect the product.



ON the shore of Lake Macatawa in Holland, Michigan, U.S.A., Parke, Davis & Co. have built what they claim to be the first plant to be completely designed and built for the synthetic production of an antibiotic. The antibiotic is chloramphenicol, the only drug of its class yet to be made synthetically on a commercial scale, which is marketed by the firm under the name *Chloromycetin*. This is not the only completely new plant for the manufacture of this antibiotic. There is one at Hounslow, Middlesex, operated by the firm's English subsidiary. But the Holland plant was started before the one at Hounslow and, while the latter can also make other products, the Holland plant is designed solely for *Chloromycetin* manufacture. The firm will not state how much of the antibiotic will be produced in the new plant, but its capacity is said to be as big as that of all other *Chloromycetin* plants now in operation. Thus it means that capacity for making this drug has been doubled.

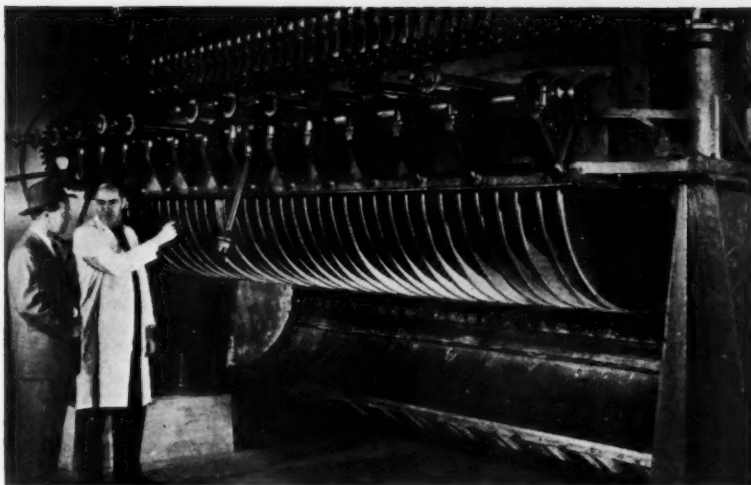
Parke, Davis have been experimenting with fermentation and synthesis as methods of manufacture for some time. Their verdict is that while fermentation makes for a more flexible production process, synthesis is more efficient from the standpoint of output per unit of space. Furthermore, with synthesis there are no contamination problems.

When *Chloromycetin* is made naturally by fermentation, only one isomer, the biologically active one, is formed. However, when the same compound is made synthetically, four special isomers result, three of which are inactive materials. These optical isomers are so very similar in properties that they can be separated only by very special means based on the physical solubilities of the materials. These resolutions must be operated within extremely narrow limits of temperature and time, and require the close attention and expert supervision of well-trained personnel.

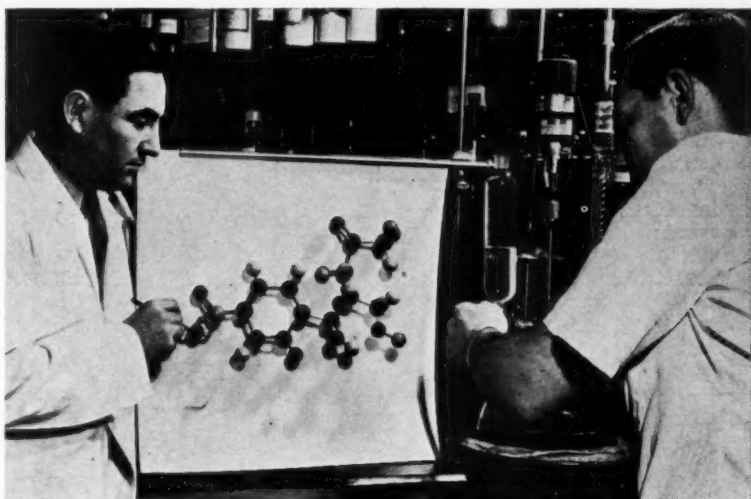
Operations and equipment

The complete synthesis requires the use of a number of operations as follows: three condensations, three hydrolyses, two acetylations, one reduction and one resolution. Each of these processes requires a production unit of a specific design which has been engineered to utilise the most modern types of equipment for carrying out the various unit operations of chemical technology such as mixing, filtration, evaporation and drying. Since many of these reactions are unusual and have seldom been operated before on the scale projected for this new plant, a number of different types of equipment and materials of construction were made necessary for the evolution of similar basic operations. Thus, five different types of filters for liquid-solid separations were built, four different types of driers for solvent removal were constructed, and unusual mixers for high-capacity agitations were built to special designs and utilising many types of corrosion-resistant materials.

Of particular interest is the distillation equipment which was specially designed for the continuous recovery of solvents. These units are of the most advanced design and are engineered for the continuous recovery of organic solvents which are discharged from the process as both binary and ternary compositions. All of this equipment is set up with automatic measuring devices and



A specially built filter press, which weighs 25,000 lb. and cost over \$25,000.



A model of the 'Chloromycetin' molecule demonstrated by two members of the research team responsible for the mass production synthesis of the antibiotic.



'Chloromycetin' being packed and labelled for shipment all over the world.

controls and is built of stainless alloy to combat the corrosion problems involved.

Solvents storage

To handle the storage of organic solvents, a segregated tank farm has been constructed with a capacity of more than 100,000 gal. The tanks in this area are safeguarded by the most modern protective devices and are buried in the interest of the protection of life and property. Automatic controls meter these solvents to the various processes as required for operations.

The disposal of the large volume of liquid wastes generated by these chemical processes was a particularly acute problem because of the toxicity of the waste and the location of the plant in an area where fresh water is a very valuable natural resource. The problem was finally solved by drilling a well more than 1,500 ft. deep into a porous geological stratum below the surface of the fresh ground water levels. The disposable wastes are injected into this stratum by forcing them under high pressures down the well casing with high-capacity pumps.

The requirements for cold-water supply for condensation equipment made necessary the installation of refrigeration units which are capable of reducing low-temperature media equivalent to the manufacture of 400,000 lb. of ice per day.

Also of interest is the fact that all of the processes are as completely instrumented as possible. In order to protect this instrumentation, even the air supply for the control equipment is passed through special drying units to reduce the water vapour content to extremely low figures.

Future Articles

Graphic and Supervisory Control Panels

by A. Pollard, B.Sc., A.R.I.C.

Liquid Cyclones

by S. Hesling, M.Sc., A.R.I.C.

Fluorspar and Fluorine

by J. L. Boyle, Ph.D.

Clad Steel Chemical Plant

by H. Canler, Dipl.Ing.

The Modern Approach to Chemical Engineering Research Problems

by J. M. Coulson, M.Sc., F.I.D.

Chemical Engineering Review: Distillation

by H. H. Jones, B.Sc.Tech., A.M.I.Chem.E.

Owing to pressure on space

The Design and Layout of Radiochemical Laboratories

by J. W. J. Fay, Ph.D., D.I.C.

has been held over to the September issue

Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Distillation column for hexane

An olefine-free mixture of normal hexane, methylcyclopentane and benzene, such as a commercial *n*-hexane cut, is fractionated under a reflux ratio of at least 20:1 in a distillation column having the equivalent of at least 20 theoretical plates. The overhead product consists essentially of the *n*-hexane-benzene azeotrope containing 4.3% by weight of benzene, and is an advantageous feedstock for a hydroforming process. The bottom product, when free of *n*-hexane, can be used as aviation fuel. An Iranian '*n*-hexane' cut of boiling range 68° to 74°C. was distilled in a batch column equivalent to 100 theoretical plates (at total reflux), at a reflux ratio of 200 to 1. Over 90% of the total *n*-hexane was recovered, in the form of the azeotrope with benzene, completely free from methylcyclopentane. The azeotrope was passed, together with hydrogen, over an activated molybdenic oxide-on-alumina catalyst at 1,000°F. and under a gauge pressure of 200 lb./sq. in. The aromatic content of the product was 58% by weight.—617,920, *Anglo-Iranian Oil Co., Ltd., J. Owen and O. M.K. Collis.*

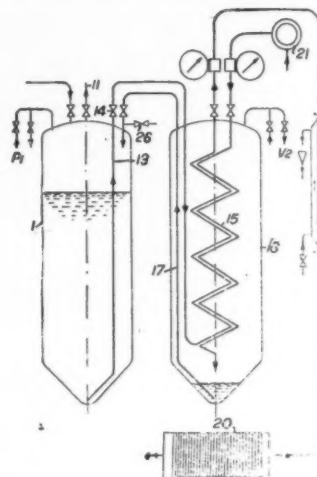
Dehydrating tetrahydropyran by distillation

Water is removed from tetrahydropyran/water mixtures by submitting the mixture to a distillation which is continued until the vapours therefrom give a condensate which, on cooling and standing, ceases to separate into two layers; tetrahydropyran being added to the mixture if the latter contains more water than the azeotrope, in an amount sufficient to ensure that, in a batch process, the proportion of tetrahydropyran in the still increases as the distillation proceeds, or that, in a continuous process, dry tetrahydropyran can be withdrawn continuously from the base of the distillation column. In the example, 500 parts by weight of tetrahydropyran containing 15 parts of water were boiled in a still fitted with a fractionating column, condenser and decanter. The condensate was passed to the decanter and the top, tetrahydropyran-rich, layer which separated was returned to the top of the column. Fifteen parts of the lower aqueous layer were collected at a still-head temperature of 71° to 75°C. The distillation was then continued at reflux ratio of 5:1 and about 27 parts of a wet fraction removed at a temperature of 75° to 88°C. The remainder of the tetrahydropyran was then distilled off in a dry condition. The aqueous layer was submitted to redistillation and approximately 1 part of wet tetrahydropyran obtained. This and the moist intermediate fraction may be recycled to the initial distillation process. Specification

592,919 is referred to.—619,976, *J. G. M. Bremner, D. G. Jones, R. R. Coats and Imperial Chemical Industries, Ltd.*

Hardening fatty acids

The discontinuous hardening of fatty acids and/or their glycerides comprises circulating the fat to be hardened mixed with a catalyst in a hardening container 1 in contact with hydrogen, the fat being first preheated by using the heat content of



the hardened fat from a preceding operation. Before passing into the hardening container, the fat to be hardened is passed through a heat-exchanger 15 located in a storage container 16a and heated by the hardened fat-catalyst mixture which is led simultaneously and in counter-flow through the heat-exchanger. The fat to be hardened is then fed into the storage container, from which it is then filled into the hardening container. A pump 21 supplies the fat to be hardened to the heat-exchanger 15 from which it empties to the storage container. In operation, when the hardening process of a previous fat has been completed in the container 1, hydrogen above the liquid layer is removed through a blowing-pipe 11 and replaced by an inert gas from a pressure pipe P1. The storage container is evacuated by a vacuum pipe V2, a valve 14 opened, and the inert gas forces the fat-catalyst mixture through a pipe 13, heat-exchanger and thence eventually to a filter press 20. The procedure is now reversed, container 1 being placed under vacuum and the unhardened fat passing over through a pipe 17, catalyst being added through a valve 26. A number of hardening containers may be used with one filter press unit because of the time difference required for their operation.—619,961 *Nordiske Fabriker, De-No-Fa A/S, and C. F. Holmboe.*

New Drug and Dyestuffs Factory in India

JOINT INDIAN-U.S. ENTERPRISE

AT the town of Bulsar in the semi-desert land around Gujerat, 150 miles north of Bombay, a new chemical factory has been built. The importance of this enterprise is indicated by the fact that the Prime Minister of India himself opened the factory recently.

The factory is to produce primarily dyestuffs and sulphonamides. Hitherto India's dyestuff industry has been based on the blending of imported dyes. The new factory will make them from imported intermediates, technically a big step forward and economically the means of saving India \$500,000 a year in foreign exchange, if the savings made in producing sulphur dyes are also counted.

Prime mover in the enterprise is an Indian industrialist, Mr. Kasturbhai Lalbhai, whose interest in dyes stems from his ownership of several textile mills. With him are several other Indian industrialists who together have subscribed 90% of the capital of \$3,500,000 needed to start the company, the name of which is Atul Ltd. The other 10% of the capital has been subscribed by American Cyanamid Inc., who have also supplied the technical knowledge and trained the technicians needed to run the factory. With such close ties with American Cyanamid it is natural that Atul will initially make products in which this American firm have long specialised. Besides dyes and sulphonamides, these will be the new 'wide-spectrum' antibiotic, aureomycin, and the anti-anaemia drug, folic acid.

Dyestuffs manufacture

Present annual production capacity of Atul is 1,000,000 lb. sulphur dyes and 3,000,000 lb. azo dyes. These will con-

stitute a range of about 20 basic dyestuffs widely needed in India. Sulphur black will be the first to be made. Later it is hoped to make alizarine dyes. As mentioned, the dyes will be made from intermediates imported from American Cyanamid plants. Eventually the Indian chemical industry itself will produce the needed intermediates; already one company is making benzole.

Drugs

With the manufacture of dyestuffs it is logical to couple the production of sulphonamides, and Atul aim initially to make 100,000 lb. p.a. of these versatile drugs which are badly needed in India to combat widespread diseases. Sulphadiazine will be the principal product. Local needs have also prompted the manufacture of folic acid for the treatment of anaemias of pregnancy and malnutrition.

Perhaps the most interesting of the drugs on Atul's production schedule is aureomycin, which is effective against many diseases and is easy to administer.

Production facilities

The factory area consists of 850 acres, so there is plenty of room for expansion. Water is a fundamental necessity of all chemical manufacture, and to supply the factory a reservoir of 1,000 acres has been made by damming the Par river. Settling tanks for effluent disposal have also been built.

The factory at present consists of a power plant, office and laboratory building, warehouse, three manufacturing buildings and housing for administrative staff and workmen.

The power plant is not the largest in

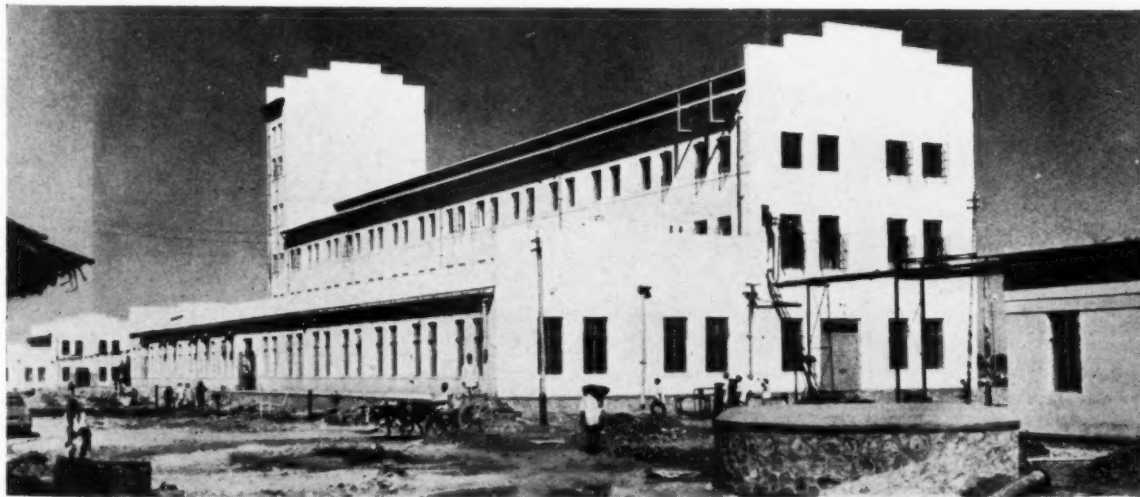
India, but is claimed to be the most modern. It has a 58 ft. high combustion chamber with an output of 25,000 lb./hr. of compressed steam. It supplies steam and generates current for both the dye and pharmaceutical sections of the plant.

The laboratory will investigate customers' individual dye problems. It is staffed, like the plant, by Indian chemists, some of whom have American degrees, and trained local workers.

The lay-out of the factory itself has been admired by visiting technicians from Britain, Japan and Switzerland. The main part of the dye section is in a three-story building with a 90 ft. tower at one end, housing the ice plant. To make the scheduled quantity of azo dyes, 40 tons of ice and 10 tons of refrigerated water are required each day. This comes from an automatic ice-making machine, assisted by a barometric leg vacuum cooler. The ice is fed by gravity to the solution vats on the third floor in which the initial solutions are made up. These are again fed by gravity to the 10,000-gal. coupling vats, just above floor level on the second story.

The vats have been made locally from Indian teakwood. They are considered to be almost equivalent to the precision-made vats normally used in the West but, being of local materials, have cost half as much. However, the reaction of teak to acids and alkalis is not yet known, so the Atul vats are being carefully watched to see whether they will last as well as those in the United States, where cypress is normally employed.

After leaving the coupling vats, the precipitated dye flows by gravity to centrifugal pumps which convey the dye slurries to 56 in. plate and frame filter presses. The isolated press cake is then loaded into



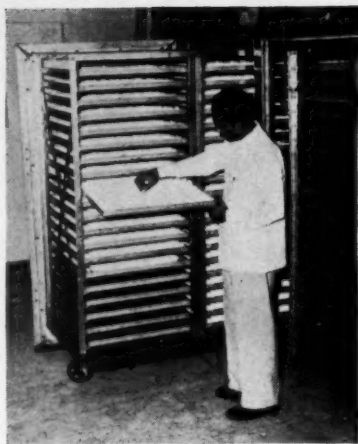
The azo and sulphur dyestuffs building with its 90-ft. tower housing the ice plant. Solution vats are on the top floor and the coupling vats on the second.

trays and dried in recirculating air truck driers. It is finally dumped into containers and carried back to the third floor, from which it is fed down through the grinders to the blenders and then into finished packages ready for shipment.

This method of manufacture is very similar to that employed at Bound Brook, New Jersey, U.S.A., at the plant of the Calco Chemical Division of American Cyanamid. In addition to providing some of the capital, the American firm has given advice on the purchase of equipment and some of the raw material. Atul technicians have also received training at Bound Brook, the results of whose laboratory research are at the disposal of the Indian firm. Also American technicians have visited Bulsar to train workers locally. However, American Cyanamid has no share in the actual management.

The Atul project is based on a 20-year development programme, and it is planned eventually to become an industrial township housing 8,000 people and supplying India's 362,000,000 population with most of the dyes and drugs required. This is a not inconsiderable ambition. If it is realised it will justify the choice of Atul for the name of the firm, because in Hindustani this word means 'incomparable.'

Taken in conjunction with the recent



Inspecting the first batch of sulphadiazine leaving the drying ovens.

opening of the great Sindri fertiliser plant,* eventually planned to become the Billingham of India, the Atul enterprise is a landmark in the development of a chemical industry in India. It marks the beginning of a fundamental change in world chemical trade of cardinal importance to the British chemical industry, which for many years has regarded India as its best customer.

* See CHEMICAL & PROCESS ENGINEERING, May, 1952.

Mechanical Handling in Fertiliser Manufacture

MANY manual operations in the manufacture of fertilisers have been replaced by mechanical methods to achieve higher productivity and economy of manpower. In fact, mechanical handling equipment is so extensively used that only selected features which may be of special interest were dealt with in a paper, "Some Aspects of Mechanical Handling in the Fertiliser Industry," read by J. P. A. Macdonald, of Scottish Agricultural Industries Ltd., at a recent Edinburgh meeting of the Fertiliser Society. In order to apply common mechanical handling technique to this industry, however, particular attention must be paid to the chemical and physical nature of the materials themselves.

By far the most commonly used equipment is the rubber belt conveyor. It is applicable to practically all solid materials other than relatively hot substances and very fine powders. Special provisions are, however, required, particularly for handling materials susceptible to caking in a hard and sharp form, which often leads to build-up and the resultant damage to the equipment. Many modifications have to be introduced to meet specific conditions. These include specially inclined and curved feeding chutes from hoppers to reduce

wear from the falling materials on the conveyor belts. Rubber strips and guides have to be used to prevent spillage which is not only a waste but can completely block the handling systems. In elevators handling sticky material, particularly superphosphate, there is often difficulty from build-up inside the buckets. In certain cases this can be kept down by routine cleaning, for example, by tapping each bucket on the downward leg in order to clear accumulated superphosphate before it has had time to become set. Unfortunately it is not always possible to ensure that this practice is carried out, nor can there be any guarantee that excessive zeal will not be displayed by the use of a sledge hammer instead of a mallet, with obvious consequences.

Rubber equipment

Rubber is used a great deal for fertiliser handling equipment. It is found in practice that not only is material more easily removed from rubber-sided chutes and hoppers but there also appears to be less tendency for it to adhere initially. This may be due to the fact that there is always a certain amount of flexing going on and the material will not build up under such

conditions. The author states that trial units of this type have been so successful that his firm have decided to use the principle wherever appropriate and to form new chutes by a light angle frame work infilled by conveyor belting.

Automatic crane

One interesting piece of equipment developed was an automatically operated crane. It had to be able to fill the store from railway wagons at 80 tons/hr., whereas only 20 tons/hr. were required for feeding the mills. One solution would have been to have sufficiently large hoppers for the 16 to 20 working hours in a day. These would have been expensive and the alternative was to have an automatic control system on the crane so that it would recover from the store without attendance, and in accordance with mill requirements. There was clearly some risk in this new departure but the crane was designed so that it could revert to manual control for all purposes if the automatic gear failed. The plant has already been installed and the automatic system has been tried out. Modifications are now being made and it is expected that they will make the crane sufficiently reliable for automatic operation. The intended method of operation is that the crane driver will be available during the day for normal unloading of cargoes, levelling up of stock and work of this nature. During the two night shifts no crane man will be on duty and recovery of phosphate will be carried out by the mill operator.

Cleanliness

In general, much work is being done on the modification and improvement of existing mechanical handling equipment in the fertiliser industry. Attention is being given to design to improve reliability by the reduction of spillage, prevention of build-up and suppression of dust. Handling of the fertiliser industry's raw materials and finished products must remain to some extent a dusty or pasty operation and unless constant attention is paid to cleaning, the damage to plant can be considerable. It costs something to keep handling plant clean and very often a statistician may prove that it is cheaper to let a conveyor wear itself out rapidly and be replaced than pay the cost of keeping it clean. However, the human factor must be considered and a well-kept plant has intangible advantages, such as the improved outlook of the operator and greater interest in the plant, high standard of maintenance and the consequent reflection on time lost due to break-down as well as longer life and greater safety. If the position is to improve materially, measures to minimise the amount of spillage, build-up and dust must be pursued and no peace given to the design side until things are better. Nevertheless it must be recognised that at the best the process will remain a dirty one and there is no circumventing the necessity for regular cleaning by manual effort.

Book Reviews

Corrosion resistance of tin

Since more than half the usage of tin is in coatings for the protection of steel and other metals from rusting and corrosion, the Tin Research Institute has now published a book* on this subject by Mr. S. C. Britton, M.A., who is responsible for the research work on corrosion at the Institute.

This book is in three parts. The first deals with the corrosion of tin itself, the second with its alloys and the last with coatings of tin and its alloys upon other metals.

After a section on atmospheric corrosion, both indoors and outdoors, there are sections on corrosion by acids and by alkalis in both of which the influence of atmospheric oxygen is often decisive. Milk products, an important class of materials which are mainly treated and transported in tinned equipment and vessels, are separately discussed.

Alloys of tins are discussed in Part II, the alloys dealt with principally are solders, bearing metals and bronzes.

Tin coatings and tin-alloy coatings are the subject of Part III (31 pages). There is a brief account of the various methods by which the coatings can be produced. Experiences with canned foods figure largely in the discussion of tinned steel containers for acid products and the effects of oxygen and of inhibitors are reviewed.

The book concludes with a review of the properties of the following tin-alloy coatings which have found increasing applications in recent years: tin-lead, tin-zinc, tin-cadmium, tin-copper (speculum especially) and the new tin-nickel electroplate which has outstanding qualities of corrosion and tarnish resistance.

Vinyl polymers

The field covered by this work† is much wider than that indicated by resins which have the term 'vinyl' in their commercial names. The author has treated 'vinyl' not only in its strictly chemical sense and included all materials which are derived from monomers containing a $\text{CH}_2 = \text{CHX}$ group, but has also included more highly substituted ethylene derivatives.

The main headings are: styrene, acrylic derivatives, vinyl acetate and chloride, vinylidene chloride and fluoro-derivatives, ethylene and miscellaneous vinyl derivatives. Throughout there are many references to technical literature and to patents for further study.

Primarily the book is written for the technologist interested in the properties of the resins and the physics and chemistry

**The Corrosion Resistance of Tin and Tin Alloys*, by S. C. Britton. Tin Research Institute, 1952. Pp. 77 + Index. 3s. 6d. net.

†*Vinyl and Related Polymers*, by C. E. Schildknecht. Pp. XI + 723. Chapman & Hall, 1952. 100s.

New Effluent Plant



Above: General view of the effluent purification plant at the Ruabon works of Monsanto Chemicals Ltd., looking north-west.

Below: One of the twin strong-effluent balancing pits which are of unusual design. These pits are 20 ft. diam. and 20 ft. deep. They are constructed within an outer pit of 25 ft. diam., the space between being filled with clean water to prevent leakage of this liquor into the surrounding ground. Situated within the factory area, the discharge from them is piped to storage tanks at the effluent purification plant (for further details see p. 419).



of their preparation. Particularly useful is the wide coverage given to derivatives which, although they have not so far proved to be of any commercial importance, are of value in indicating trends of research and confirmation of various theories regarding the effects of substituent groupings, limited cross-linking, etc.

The treatment throughout is realistic and practical. The known limitations of products are stressed as well as their advantages. Theories of structure are well presented graphically by formulae and there are numerous sets of curves and illustrations of plant and equipment.

Descriptions are included of the properties and applications of fibres based on

poly-acrylonitrile and polvinylidene chloride together with references to several other fibres at present of minor commercial importance.

In certain chapters there are useful lists of trade names, although it is rather surprising to find Imperial Chemical Industries' *Welvic* misprinted several times, including the dust cover, as *Welvic*.

To summarise, 'Vinyl and Related Polymers' is a useful and stimulating book for those concerned with the chemistry of vinyl derivatives and the physics of their polymerisation and co-polymerisation. The author is to be congratulated on the scope and quality of his effort.

J. H. MARTIN, B.Sc., Ph.D., A.R.I.C.

Plant and Equipment

British 'Chloromycetin' plant

A large proportion of the wide range of plant for the manufacture of the synthetic antibiotic *Chloromycetin* at the Hounslow factory of Parke, Davis & Co. Ltd. was supplied by the Balfour Group of companies. There are three main stages of the process. The first three steps of the first stage use Pfaudler glass-lined jacketed reaction vessels supplied by Enamelled Metal Products Corporation (1933) Ltd. These vessels are arranged to give maximum accessibility to charge-hole cocks, valves, agitators and controls. Pfaudler-Balfour jacketed stainless steel units and Pfaudler glass-lined refluxing units are employed in the second stage.

To handle the several drying operations a battery of five Scott vacuum shelf dryers has been installed. All are equipped with automatic safety devices to avoid contamination or overheating of materials. Other Scott plant includes a solvent recovery unit comprising a batch distillation plant with copper fractionating column, the whole unit being manually controlled from one central operating panel.

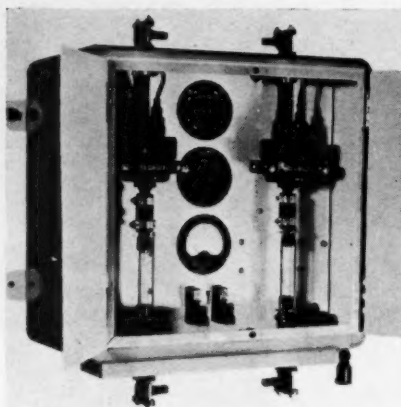
In addition, a number of Pfaudler-Balfour stainless steel condensers and Pfaudler glass-enamelled connecting pipes and fittings were supplied.

Electrolytic water sterilisation

Electrolytic sterilisation of water supplies, industrial effluents and other liquids has many advantages, and for certain conditions is preferable to the use of commercially prepared hypochlorites and other forms of chlorination. The *Clorocel* equipment supplied by the Paterson Engineering Co. Ltd. treats water by the addition of electrolytic sodium hypochlorite (E.S.H.). It comprises an electrolytic cell which converts a weak solution of common salt into E.S.H., all the products of electrolysis being available for use in the sterilising process. Nascent oxygen is formed together with the main product, chlorine, and the availability of the oxygen as well as the chlorine is an important factor in eliminating taste and smell even when using high chlorine concentrations in difficult waters.

Water purification equipment of this type is available for handling from 50-50,000 gal./hr. and above this output plants can be built up into a series of units. The most general form is that in which the E.S.H. flows directly from the cell into the stream of water to be sterilised but where salt supplies are difficult, the equipment is arranged so that a higher concentration of chlorine is built up.

It is necessary to ensure that the right grade of salt is obtained, and also that suitable storage is available. Common



Water sterilisation unit.

salt often has a large proportion of foreign matter which, if allowed to pass through the equipment, will shorten the life of the electrodes. In order to ensure ease of operation and a clean supply, two methods are available for producing the correct solution. The first involves a straining bag and is suitable for small installations or when treatment is intermittent. The bag contains specially graded salt, ready to drop into the salt solution tank. It also acts as a filter, the preparation of a clean solution taking only a few minutes. For installations required to run for long periods, a salt saturator is used, consisting of a closed vessel working under mains water pressure.

New flow meter

A new variable-area flow meter has been developed by the Fischer & Porter Co., U.S.A., in which the float is the down-flow type. The new design utilises a lower vertical extension to the rotameter float rod, carrying an additional buoyant float. This second float is inside a chamber filled with a liquid much denser than the fluid being metered and subsequently immiscible with it. Since the entire meter action is inverted, the taper of the metering tube is the reverse of conventional practice: a gasket separates the metering chamber from the extension chamber, and any conventional transmission means may be used such as the magnetic armature type.

A modified form for the lower float is also practicable, which is temperature compensating. The buoyancy of the buoyant float or any modifications can be adjusted by variations in size or by filling the float with an extremely buoyant gas or various liquids.

For further information on new plant and equipment, please complete the coupon on page 452.

Electrical equipment for chemical and process plants

A large number of electric motors are being supplied for a number of important British chemical projects by the British Thomson-Houston Co. Ltd. These projects include the Cabot Carbon Ltd. carbon black plant at Ellesmere Port, two plants for the manufacture of sulphuric acid from pyrites and oil refinery plants. In all, these plants utilise upwards of 1,100 of the company's motors. The paper-making industry has also been supplied with a large number of motor drives. These include a sectional drive for a 156-in. paper machine for making newsprint which was installed in South Africa. The machine has ten sections, each driven by a B.T.H. a.c. commutator motor with a 3:1 speed range. Electronic controls have also been supplied for a number of motors and during 1951 several new *Emotrol*-controlled drives were commissioned, including a 200-h.p. single-motor paper machine installation. A 215-h.p. *Emotrol* unit is also being supplied to Argentina for controlling a boiler fan drive.

During 1951, two 3,000-kW. motor converters were supplied to the chemical industry and four similar machines are nearing completion. A motor-generator set rated 1,040 kW., 130 V., and 8,000 A. was completed for the Electrolytic Refining & Smelting Co. of Australia Pty.

Considerable interest has been created by the d.c. switch-boards rated 40,000 A. at 250 V., manufactured for Imperial Chemical Industries Ltd. These are fitted with isolators on both positive and negative poles and an electrically operated air circuit-breaker to control the positive supply. As electro-chemical process units operate continuously over prolonged periods, a short-circuiting switch is provided to permit circuit-breaker maintenance without interrupting the supply. The incoming isolators and short-circuiting switches, each of 20,000-A. rating, are of an entirely new design. A further order has recently been given by I.C.I. for two 50,000-A. units of similar design.

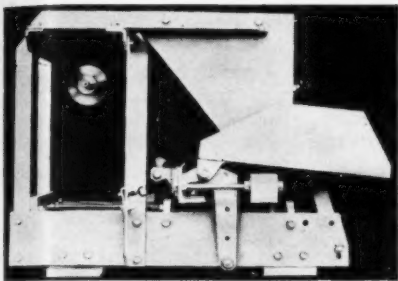
A four-stage motor-driven refrigerating compressor is being supplied to British Celanese Ltd. Working on *Freon* 12, incorporating flash gas cooling, it is believed to be one of the first centrifugal refrigerating compressors to go into commission in the U.K. Two two-stage motor-driven machines working on *Freon* 11 are being installed underground and used for cooling in the East Rand Gold Mines of South Africa.

Three turbine-driven single-stage gas exhausters are being supplied to the Woodall Duckham Co. Ltd. for the East Midlands Coal Board. These are to be installed at Wingerworth near Chesterfield, where a new carbonising plant incorporating the latest results of American experiments, and reputed to be the most up to date in Europe, is to be built.

Vibrating feeder

A new vibrating feeder, the *Velofeeder*, operates on a system of impact, by which the vibrations in the feeder are produced. Marketed by Henry Simon Ltd., it is claimed that this system has never before been utilised in industry. The feeder is said to have a wide range of performance and low power consumption.

The feed tray of the *Velofeeder* (which can be 12 in., 18 in. or 24 in. wide) can be regarded as a conveyor having a working stroke variable over a very wide range—from virtually motionless to a maximum of



Vibrating feeder.

nearly $\frac{1}{4}$ in. at 1,850 vibrations min.; the machine thus combines flexibility with a high maximum output. The motion of the tray is produced by an $\frac{1}{4}$ -h.p. motor driving a small rotating out-of-balance weight assembly that gives impulses to the 'anvil' on which it is mounted, the anvil being so arranged that it can oscillate between springs. On its rearward movement the anvil collides via a rubber pad with the feed tray, which also oscillates between springs. The springs and mountings are so designed that the two masses—anvil and feed tray—oscillate in opposite ways and collide once in every cycle; the machine is virtually self-balancing and little or no vibration is transmitted to the frame. The force of collision determines the movement of the feed tray. Variation in the force of collision is obtained by altering the mean distance between the two masses. This is done simply by turning a hand-wheel.

The machine can deal with a wide range of materials as the motive force generated by the principle outlined above ensures that even the most difficult materials are propelled evenly along the length of the tray. It is claimed, therefore, that the feeder can handle many materials, which, by reason of high moisture content or other difficult characteristics, are outside the scope of conventional feeders.

The manufacturers can offer the machine with a variety of sizes and types of tray with local or remote control. An electronic servo controller can also be incorporated to give positive automatic adjustment of feed rates in proportion to any measurable variant. Examples of the uses of the *Velofeeder* in this connection are the automatic regulation of feed to grinders and

pulverisers, thus maintaining maximum output and choke-free operation regardless of variation in material density, and the maintenance of temperature in dryers and roasters by automatic regulation of the feed.

Portable water softener for field use

Water softeners are usually employed at immovable locations. A recent innovation is the use of such softeners in portable equipment in the Texas oil fields so that boilers may be fed with the softened water. The equipment and softening materials can be moved around the oil fields with the drill rigs, to supply treated water for the powerful steam engines which drive the drilling equipment.

The equipment consists of three 42 × 72 in. tanks and one 48 × 60 in. tank, all mounted in tandem on a steel skid. The first of the 42-in. tanks is a filter, charged with a filtering compound which clears the water of mud and gross foreign matter before it enters the softeners. The other two larger tanks are the softening units, arranged so that they may be used individually or together. The fourth tank, different from the others in construction and size, is for the brine used in regenerating the softeners.

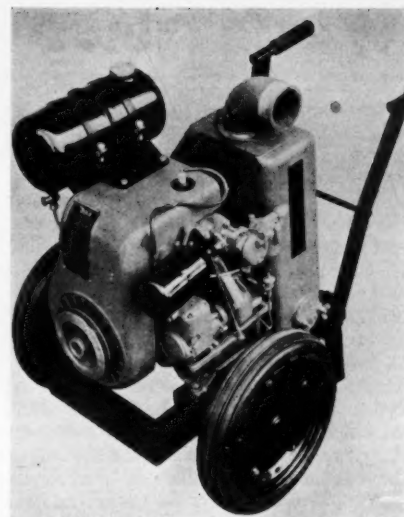
Amberlite IR-120 cation exchanger is used in the softener tanks. This is a high-capacity resin of the sulphonated polystyrene type. As the hard water passes through the resin-filled tanks, the calcium and magnesium ions (responsible for the formation of scale in steam boilers) are exchanged for sodium ions held by the resin particles.

The resin cannot continue to exchange sodium ions indefinitely, the number of ions being limited, hence it must be regenerated. Each tank is equipped with a patented multiport valve, the regeneration process being controlled by moving the position of the lever which operates the valve. At the end of drilling, the portable softener may be moved to a new location by lorry to resume operation.

Previously to the ion-exchange method, boiler compounds were used, which often cost as much as \$2,000 per well.

Portable 3-in. pump

With pumps in frequent use in factories mobility is an important factor in ensuring that they earn their keep wherever they are needed. The 3-in. centrifugal pump illustrated on this page is mounted on a strong welded angle-steel trolley with cushion tyres. The pump body is a one-piece aluminium casting; counterface of the cast-iron seal-hub is precision ground, and a special loaded carbon ring seal is fitted which requires no lubrication. On to the extended engine shaft is screwed a manganese bronze four-vane-type impeller. The 3-in. suction branch (screwed B.S.P.) is provided with clack valve, while the 3-in. discharge branch, also screwed



Centrifugal pump mounted on a welded rubber-tired trolley

B.S.P., has a swing-type flange fitting to the pump body.

Close-coupled to the pump is a 6-h.p. air-cooled petrol engine (petrol-paraffin type can also be had). Total weight of the unit is approximately 224 lb. Performance data: total head, 100 ft. maximum; suction lift, 25 ft. maximum; and maximum capacity, 15,000 gal./hr.

Accessories supplied include a suction hose strainer, hose spanner and all necessary tools. The pump is marketed by Warsop Power Tools Ltd.

Automatic welding set

Fusarc Ltd. have introduced a fully automatic welding installation for gas mains, consisting of a cantilever which allows the welding head to be raised and lowered to conform to any pipe diameter. The cantilever can motor along at welding speeds on a gantry mounted beside the roller bed, and special power-driven transverse movement to the welding head along the cantilever beam enables many types of work to be handled. The power-driven tilting roller bed is in a fixed position and, apart from providing the power rotation for the pipe when carrying out normal circumferential welds, can be tilted at a suitable angle to take single strokes for welding flanges or overlapping butt straps, which are fillet-welded externally and internally.

The idler roller unit is mounted on floor rails which can be moved to any convenient position to accommodate pipes as they are progressively built up to a maximum length of about 50 ft.

The cantilever is provided with a telescopic operator platform so that the welder can operate beside the work, and the auxiliary and generator currents are provided by a 1,000-A. generator group. Remote control and remote control contactor are provided.

World News

GREAT BRITAIN

Economic recovery: problems discussed at S.C.I. meeting

The economic difficulties now besetting the country were discussed by two speakers at the 71st annual meeting of the Society of Chemical Industry held in Aberdeen from July 7-12. In his presidential address, Mr. John Rogers, chairman of Imperial Chemical Industries Ltd., said that the period of easy selling was over. In some ways this was a good thing because it gave a breathing space to overhaul and improve plant. 'Some of you may say that revenue and capital difficulties make it extremely troublesome to do these things. Nevertheless, be optimistic and do the best you can. It has been said that the best time to spend money in industry is when you have not got any.'

Turning to the wider aspects of national affairs, Mr. Rogers said that in his view we were living in a time somewhat like the 'phony war' period of 1939. The real situation was not yet understood by most people. His way out of the difficulties would be an association of the best political brains and experience, working together with goodwill to attain the results we all wanted.

Messel Address. A serious view of our economic problems was also taken by Sir Henry Tizard, formerly chairman of the Government's Advisory Committee on Scientific Policy. He was giving the Messel Medallist's Address entitled 'The Strategy of Science,' after receiving the Messel Medal of the S.C.I. He believed that all efforts should be bent towards one goal: achievement of a balance of overseas trade. Every other project, however interesting, should be set aside in favour of attaining this end. There was too much talk about the importance of fundamental research. It was far more important to strengthen our technology than expand our science. **But, to give an example, he could think of few university disciplines more likely to produce leaders of industry than that of chemical engineering.** Science was not enough, we had to learn to apply the results of our fundamental research and not leave them for others to exploit. Here, Sir Henry quoted the well-known cases of penicillin, ion exchange resins, silicones and *Terylene* as British discoveries that had been exploited in other countries.

He was puzzled by the chemical industry's apparent lack of influence on export trade. Chemicals had constituted about 9% of total world trade for 50 years. However, the British share in this trade had declined from 22% in 1913 to 18% in 1950 while the American had risen from 10 to 36%.

It might be argued that we did not have enough money to exploit our discoveries, but God was not always with the big

battalions and he recalled Rutherford's advice in a similar situation, 'We haven't any money so we've got to think.'

About 300 members and their guests attended the meeting. Among the guests were Prof. Niels Bohr, the eminent physicist who was made an Honorary Foreign Member of the Society, a similar distinction being bestowed on M. Ernest Solvay.

Visits were paid to the local industries of Aberdeen, which include paper making, production of fertilisers and acids, food processing and wool cloth manufacture.

New S.C.I. president

The president of the Society of Chemical Industry for 1952-53 is Mr. Francis Curtis, who was installed at the annual meeting in Aberdeen. Mr. Curtis has a background of 35 years' experience in the chemical industry. He is a vice-president and director of Monsanto Chemical Co. of St. Louis, U.S.A. He is a past-president of the American Institute of Chemical Engineers (1949) and former chairman of the American Section of the Society of Chemical Industry. He has been chairman of the Division of Industrial and Engineering Chemistry of the American Chemical Society and is a charter member of the Commercial Chemical Development Association.

A 1915 graduate of Harvard University, Mr. Curtis began work in the chemical industry as a laboratory technician with the Merrimac Chemical Co., which was purchased in 1929 by the Monsanto Chemical Co. After five years in the laboratory, he was placed in charge of operating a plant. In 1925 he was moved to the sales department, where he worked for five more years until he was named head of the plant development programme. In 1935 he was transferred to St. Louis to become assistant director of Monsanto's entire development programme. In 1939 he was placed in charge of a new general development department of Monsanto, which had the task of encouraging development outside the company. In this connection, he made a number of trips to Europe and thus is familiar with chemical developments and problems there. He was promoted to vice-president and secretary of the executive committee of Monsanto in 1943 and, in 1948, was given the additional duty of co-ordinator of sales. He was elected to a directorship in 1949 and last year went to Washington to represent the company there.

During World War 2 the Army sent Mr. Curtis to the European theatre to determine the enemy's development of chemicals for war use. In 1951 he visited Great Britain, where he represented the U.S. National Production Authority on a two-man team that studied British use of American sulphur and suggested ways of

conserving sulphur and of developing new sources of sulphuric acid.

Unique pyrites-acid plant

S.C.I. members at the annual meeting in Aberdeen were able to see under construction a unique plant for the manufacture of sulphuric acid from pyrites. It is at Sandilands Chemical Works of Scottish Agricultural Industries Ltd. and, when it comes into operation early in 1953, it will produce 37,000 tons p.a. of acid from 27,000 tons of Spanish pyrites, thus replacing the existing acid plants at Sandilands and producing enough acid for fertiliser manufacture there, as well as some for other plants in the country.

The plant is of the Nichols-Freeman flash roaster-Petersen tower type, the combination being the first of its kind in the country. Pyrites are ground and dried and then burnt in the roaster to produce a gas containing 10% SO₂. This gas passes through a waste heat boiler for raising steam at 325 p.s.i. which passes through a 310-kVA back-pressure turbo-generator before being released at 30 p.s.i. for use as process steam elsewhere. After purification the cooled gas passes to the six Petersen towers which comprise, in turn, denitration, production, stabilising, regeneration and two nitration towers. In these, sulphuric acid is made in the same way as in the familiar lead chamber process in that oxidation is carried out with oxides of nitrogen. However, the strength and volume of the circulating acids is considerably greater and there is a much higher production per cubic foot of reaction space.

A novel constructional feature of the six brick towers is the use of *Alkathene* (polythene) sheeting in place of the conventional lead sheath. Granite is used for the tower filling instead of quartz, and glass is used for the acid coolers in place of cast iron.

Government aid for technological education

In a recent Parliamentary reply the Chancellor of the Exchequer, Mr. R. A. Butler, said that the Government considered that a most important means of increasing productivity in industry was to improve the facilities for higher technological education. They were convinced that that could best be done by building up at least one institution of university rank devoted predominantly to technology, and the best way of doing this was now being studied. As regards the last Government's White Paper, the Chancellor continued, the present Government fully recognised the important contribution which some technical colleges could make to higher technological education, and proposals for giving them more financial aid would soon be announced. However, the Government would not establish a non-teaching, award-making body under the title of the Royal College of Technology.

Engineering company's jubilee

The fiftieth anniversary of the Paterson Engineering Co. Ltd. was recently celebrated by a reception at the Apothecaries Hall, London. A large number of guests were received by Sir William Paterson, founder and chairman of the company, and by Lady Paterson. The principal speakers were two friends of his youth, Lord Waverley and Prof. Sir Alexander Gray. As young men the three had been together for their engineering training in Scotland.

William Paterson was born in 1874 and received his technical training at Heriot Watt College and apprenticeship at James Bertram & Sons. He formed the Paterson Engineering Co. in 1902 when he believed he had found a solution to the problem of boiler failures in power stations resulting from the presence of oil in feed water. Initially the company was occupied with providing efficient and economical means for softening and filtering water for industrial purposes and later they entered the field of water purification for the public drinking supply.

In 1939, Paterson was asked by Lord Waverley, then Sir John Anderson, to devise an air-raid shelter capable of rapid production in very large numbers at low cost. At the jubilee reception, Lord Waverley gave full credit for the well-known Anderson shelter to Paterson and the Paterson Engineering Co. Ltd. Sir William was knighted in 1944.

Private imports of fertilisers permitted

Arrangements have been made for licensing the private import of those fertilisers (mainly phosphate rock, potash salts, superphosphate and basic slag) which, as recently announced by the Ministry of Materials, have ceased to be imported on public account. Imports will be permitted from any country other than Canada, U.S.A. and other dollar countries. Full information can be obtained from the Board of Trade, Import Licensing Branch, Romney House, Tufton Street, London, S.W.1.

Price changes

Tungsten ore. The selling price for tungsten ore of standard 65% grade and ordinary quality has been reduced to 447s. 6d. per long ton unit delivered consumers' works with effect from July 12, according to a recent Ministry of Materials announcement.

Copper. The price of electrolytic copper has been increased by £6 from £281 to £287 per ton delivered consumers' works from July 5, according to the Ministry of Materials. Three weeks earlier it was increased by £50 per ton.

Lead. The price of imported good soft pig lead has been reduced from £137 to £131 per ton delivered consumer's works from July 10, according to the Ministry of Materials.

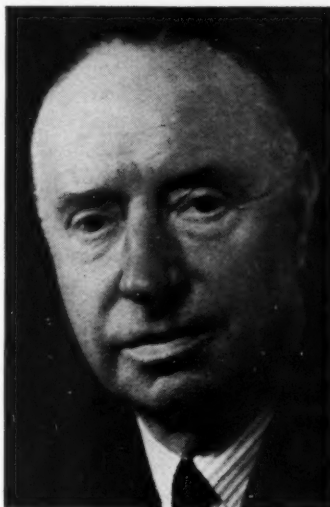
From August 22, 1952

Chemical & Process Engineering

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MR. HENRY J. ROSS

who as chairman of the Scotch Whisky Association since 1945 received a knighthood in the Birthday Honours List, has been since 1948 chairman of the Distillers Co. Ltd., which he joined at the age of 17 in 1911 as a yeast plant apprentice. From 1914 to 1916, when he was invalided from the Service, he served with the R.N.V.R. and has since retained a keen interest in yachting. The industrial interests of the D.C.L., which have become increasingly important in recent years, include, in addition to the production of industrial alcohol, yeast and malt extract by departments of the parent company, the bulk manufacture of organic chemicals by British Industrial Solvents Ltd., of plastics by British Geon Ltd., British Resin Products Ltd., and BX Plastics Ltd., and of biochemicals by the Distillers Co. (Biochemicals) Ltd.

Personal

Mr. Godfrey H. Owtram has joined Petrochemicals Ltd. as managing director. He is 45 years old and has had wide administrative experience in the textile, engineering and chemical industries. He is also chairman of Peter Crook Ltd., cotton spinners, director of the Yorkshire Dyeing & Proofing Co. and associated companies, founder of New Metals & Chemicals Ltd., member of the council of the Institute of Directors and chairman of their Taxation Committee. He replaces **Dr. F. Kind** and **Dr. G. Tugendhat**, who recently resigned as joint managing directors. Dr. Tugendhat has also resigned from the board, but Dr. Kind will remain a director.

Mr. E. G. Pickering has been appointed a joint managing director of Johnson, Matthey & Co. Ltd.

Mr. K. B. Ross, formerly general refineries manager in Persia for the Anglo-Iranian Oil Co. Ltd., has joined the board of Costain-John Brown Ltd. This company is owned jointly by Richard Costain Ltd. and John Brown & Co. Ltd., and is engaged among other things in the building of refinery and chemical plants. Several contracts are now on hand and it is expected that this side of the business will be developed with the help of Mr. Ross.

Mr. M. K. Schwitzer has been appointed manager of the Chemical Division (Europe) of Armour & Co. Ltd., London. This Division deals with the whole range of fatty acids and their derivatives produced by Armour's new plant at McCook, Illinois, U.S.A. These products include the *Neofats*, *Armids* (amides), *Arneels* (nitriles), *Armeens* (amines), *Arquads* (quaternaries) and many others.

Mr. Brian H. Turpin, technical and sales director of Quickfit & Quartz Ltd., manufacturers of scientific and industrial glassware of Stone, Staffs, a member of the Triplex group of companies, has been elected a member of the Stone Urban District Council.

Chemistry research fund

The research fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About £700 p.a. is available for this purpose, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund and from other sources. Forms of application together with the regulations may be obtained from the General Secretary, the Chemical Society, Burlington House, Piccadilly, London, W.1.

BELGIUM

New catalytic cracker

A *Houdriflow* catalytic cracking unit is to be installed at the Antwerp refinery of Albatros S.A. Belge pour le Raffinage de Petrole, according to a recent announcement by Houdry Processes Corp., and their foreign representatives, World Commerce Corp. S.A., New York. This moving-bed installation, employing a gas-lift for catalyst circulation, is designed for a nominal capacity of 3,600 barrels/day. It will be the 85th *Houdry* licensed catalytic unit.

The agreements just concluded for the expansion and modernisation of the Antwerp refinery also call for a feed preparation unit, a gas recovery and stabilisation unit, a plant for the polymerisation of light olefins produced in *Houdriflow* cracking operations, and new facilities for treating straight-run and catalytic fuels.

Petrocarbon Ltd., Manchester, England, are consultants to Albatros S.A. The mechanical engineering, drafting and procurement are being handled by Head Wrightson Processes Ltd., of London, working in conjunction with Houdry Process Corp.

RUMANIA

Natural gas for Hungary

A joint Hungarian-Rumanian company for the exploitation and chemical processing of natural gas is to be set up under a long-term economic co-operation pact reached between the two countries. Gas from Rumanian deposits will be conveyed through a jointly constructed pipeline to Hungary, where it will be chemically processed.

TURKEY

New sugar factory

A \$4,000,000 sugar factory for processing 1,800 tons/day of sugar beet is to be built at Adapazar. It will be constructed by the German company, Buckau R. Wolf A.G., who have already built three of the four existing sugar factories in Turkey.

BRAZIL

Fertiliser factory to be built

A company recently established in collaboration with the Société des Potasses d'Alsace, France, known as Potassa e Adubos Quimicos do Brazil, will build a fertiliser plant at Santos at a cost of several million dollars. The factory will have an annual capacity of 30,000 metric tons of mixed fertilisers and will use Chilean nitrate and Alsatian potash.

Synthetic resin plant imported

A complete chemical plant which will manufacture synthetic resin copolymer emulsions has been shipped to Sao Paulo, according to the American Polymer Corp. It will be ready for operations early next year. A new corporation, Polymer Productos Quimicos do Brazil, S.A., has been formed to run the plant, which will polymerise a wide range of monomers, producing specialities used in the leather, paint, plastic, textile, adhesive and agricultural fields.

SOUTHERN RHODESIA

New cement factory

The Premier Portland Cement Co. of Rhodesia is to erect a cement factory at Moffat, near Gwelo, on a 100-acre site. The factory will have an estimated output of 200,000 tons p.a. of cement.

INDIA

Synthetic gem factory

India's first synthetic gem factory will be in Madras State and will go into production in July, 1953, according to Mr. M. V. Sarma, a sponsor of this new industry. The factory, jointly owned by Indian and Swiss capital, will be built either at the hill station of Ootacamund or Pykara in the Nilgiri hills. An existing synthetic gem factory in Switzerland is being dismantled and shipped to Madras for assembly on the site.

According to the agreement concluded between Swiss and Indian manufacturers, the capital, 3,500,000 rupees, for the new factory, is to be shared between Swiss and Indian industrialists on a 49-51% basis. The Swiss will supply the machinery and a team of technicians. The production target proposed for the factory is 12 to 16 tons p.a.

In India, synthetic stones are used for jewellery only. At present there are about eight synthetic gem factories in the world—five in Switzerland, and one each in France, Germany and America—with a total production of 400 tons p.a.

AUSTRALIA

Liquid helium produced

Recently helium was liquefied by research workers of the Commonwealth Scientific and Industrial Research Organisation in Sydney. Liquefaction at the rate of $\frac{1}{2}$ gal./hr. was carried out in a cryostat. The machine used was made at the National Standard Laboratory of the

organisation's division of physics. A temperature of 3° above absolute zero, or -485°F., was obtained at one stage of the experiments.

Liquid helium has several peculiar properties. When cooled to temperatures of the order of 2°C. above absolute zero, it becomes a 'super fluid' with apparently no viscosity, and an ability to conduct heat almost instantaneously.

Brown coal gas plant

A new plant to produce gas from brown coal in the Gippsland of Victoria, will be started this year. From a million tons of briquettes, 33,000,000 cu.ft. of gas, 8,000,000 gal. of tar, 2,500,000 gal. of high-octane motor spirit, 12,000,000 gal. of petrol and 10,000,000 gal. of fuel oil will be obtained, according to the Premier of Victoria.

New zinc coating process

A process claimed to permit a permanent zinc coating to be applied to any iron or steel structure before or after erection, has recently been patented by Dimet Pty. Ltd., of Melbourne. It involves the application by brushing of *Galvanite*, a compound containing metallic zinc and other inorganic products in a water-soluble metallic silicate vehicle.

Galvanite is usually applied to surfaces that have been descaled by sand-blasting or wire brushing. After application the treated surface is heated to a temperature of between 300° and 400° F. to fuse the coating and make it insoluble in water. This low temperature is claimed to avoid the distortion which may be caused by ordinary galvanising.

The process is said to give a weatherproof coating resistant to temperatures of up to 600° F. in air, water and petroleum. The coating is also claimed to be impervious to food and fruit acids.

UNITED STATES

New plant for fluorocarbon plastic

Plans for increased production of the plastic *KEL-F*, polytrifluoro-monochloroethylene, which has a high resistance to heat, moisture and chemical action, have been announced by the M. W. Kellogg Co. Scheduled to go into operation before the end of the year, a new \$1,000,000 plant is under construction at Jersey City.

One of the first important industrial uses of this plastic was in the Oak Ridge atomic research station gaseous diffusion plant, which specified it for its high resistance to corrosion. Since the war its application has been developed in the electronics, aviation, packaging and food-stuffs industries as well as the chemical industry. *KEL-F* diaphragms have been used in diaphragm-type valves, providing the necessary flexibility over a wide temperature range with the addition of complete inertness to the most corrosive chemicals. A more recent application is a lining made for a large chemical vessel handling an extremely corrosive acid.

The Leonard Hill Technical Group

Articles published in some of our associate journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist—Micro-Organisms and Nutrition; Acid Base Chemical Indicators; Anti-Convulsant Drugs; Progress Reports on Perfumery and Detergents.

Food Manufacture—Lecithin in Food Processing, Part II; Food and Agriculture Groups in Holland; Fruit and Vegetable Utilisation in America; Margarine Manufacture in France.

Petroleum—Canadian Oil before Leduc; Alberta Oil Industry; Athabasca Tar Sands.

World Crops—Soil Erosion in Ceylon Tea Plantations; Agriculture in China; Aspects of Colonial Agricultural Law; Egyptian Cotton, Part III.

Paint Manufacture—Manufacture of Stencil and Duplicating Inks; Zinc Dust as a Protective Pigment.

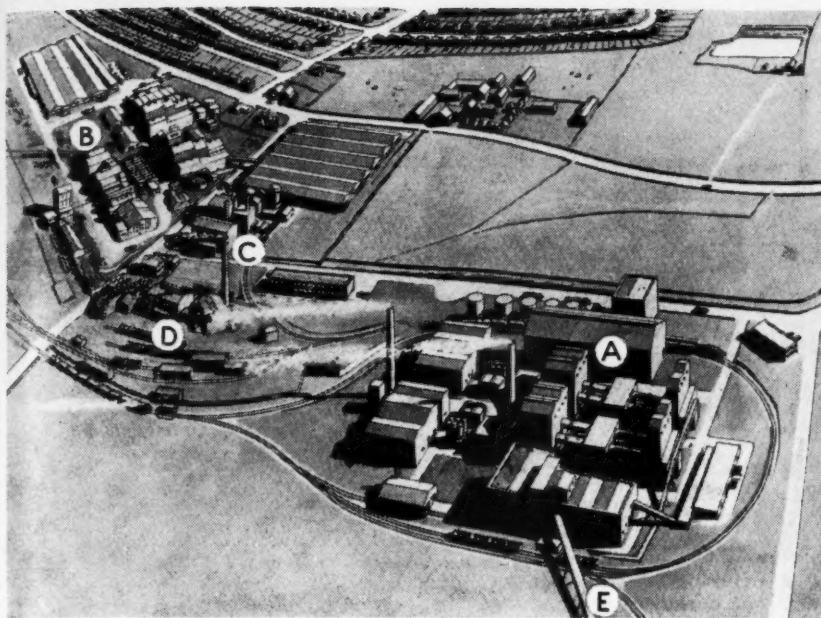
Textile Industries—Regenerated Protein Fibres from Keratin.

Muck-Shifter—Development of Multi-Purpose Excavators, Part I; Controlling Muck-Shifting Operations with Radio Telephones.

Atomics—Mobile Radiological Laboratory; 15,000,000 Electron Volt Linear Accelerator.

Building Digest—Stone Cutting Machinery; First Plastic House.

Pottery and Glass—Reconstruction of the Devon Pottery; Domestic Pottery Today, Jugs.



Aerial view showing: (a) Projected sulphuric acid-from-anhydrite works of Solway Chemicals Ltd. at Whitehaven, England; (b) Existing factory of Marchon Products Ltd.; (c) Phosphate plant in the course of erection; (d) Ladysmith power station operated by Marchon; (e) Conveyor connecting an anhydrite mine and works (see **CHEMICAL AND PROCESS ENGINEERING**, July 1952, p. 386).

The liner was completely fabricated from *KEL-F* sheet and tubing and measures 18 ft. long by 3 ft. diam.

Phenolic resin production increased

Expansion of research and production facilities to meet the foundry industry's increasing demand for phenolic resins has been announced by the Monsanto Chemical Co. Mr. E. L. Hobson, assistant general manager of the Plastics Division, said that four new plastics products for the foundry industry had been developed. He estimated that the company's production of resins for the foundry industry's shell mould process would increase 100% this year and under the accelerated research and production programme the output of standard and new resins for the shell mould process should double in 1952. The new products were the results of a six-year research programme built around the shell mould process, which substitutes a thin shell of sand and resin for the large quantities of sand used in older processes.

Rubber company expansion

The Naugatuck chemical division of the U.S. Rubber Co. has announced a major expansion of facilities for producing rubber latex and plastic materials on the west coast. The division has completed a new plant in Los Angeles which will serve as the firm's western sales headquarters and enable the division to keep pace with its expanding volume of west coast sales. The plant will also house technical service laboratory facilities for compounding and storing natural and synthetic rubber latex, and warehousing of resins, plasticisers, rubber chemicals and agricultural chemicals.

Greater cadmium and germanium recovery

Increased recovery of lead, cadmium and germanium sulphides from zinc sulphide concentrates is foreseen as the result of laboratory experiments carried on at the Mississippi Valley Experiment Station of the Bureau of Mines at Rolla, Missouri.

A bureau report describing tests during which volatilisation in both inert and reducing atmospheres, and also in a partial vacuum, resulted in recoveries as high as 90%, has recently been released. The zinc sulphide concentrates used in the experiments were typical of those produced in the tri-state district of Missouri, Kansas and Oklahoma. Temperatures used ranged from 700 to 1,050°C.

Chemical treatment of ore concentrates

The treatment of ore concentrates by chemical methods instead of the customary smelting and refining techniques is being developed by the Chemical Construction Co. and, after four years' research and pilot-plant work, has reached the stage where commercial applications are feasible.

First commercial use will begin this summer when the Chemical Construction Corp. expects to complete a \$2,500,000 cobalt refinery for a mining company near Salt Lake City, Utah. This refinery will increase world output of the metal, most of which comes from Central Africa, by more than 40%. It will daily process 35 tons of 20% cobalt concentrates from Idaho-mined cobalt. This will result in yearly production of about 2,000 tons of pure cobalt, about one-half of the U.S. consumption of the metal in 1950.

A \$5,000,000 project, now being built at Fredericktown, Missouri, should be finished by mid-1953. An annual production of 700 tons of cobalt, 900 tons of nickel, 700 tons of copper and 7,500 tons of fertiliser-grade ammonium sulphate is planned from this refinery.

A \$17,000,000 nickel refinery is being built at Edmonton, Alberta. It is scheduled to begin operations towards the end of 1953, turning out mostly nickel, but also small quantities of cobalt and copper from sulphide ores.

Active competition in the chemical markets foreseen

Ambrose R. Chantler, president of the Synthetic Organic Chemical Manufacturers Association, reporting on the international trade situation at the annual meeting in June, said that the duty-lowering effects of the Torquay conference posed a threat to the domestic chemical industry if there was a rise in the imports of key intermediate chemicals. He predicted that the instability of the world economy with its devalued currencies and opportunities for price manipulation would create extremely active competition from foreign sources in the year ahead.

Oxidation-resisting metal powders

A new method for processing metal powders, which is claimed to eliminate oxidation and give metal powders good stability, has been developed by the Glidden Co. Normally, metal powder agglomerates are produced in storage by oxidation. Amounts vary seasonally and according to the grade. Screening removes some, but others pass and cause local non-uniform briquette pressures, non-uniform sintering growth or shrinkage and difficult sizing, all of which increase scrap losses. *Resistox* metal powders are claimed to have better mixing characteristics which result in alloying improvement in sinterings. They are also claimed to prolong the life of dies, since they have better compressibility and are less abrasive than oxidised powders.

Manganese from slag

The U.S. steel industry is developing three processes for recovering manganese from the slag dumps of open-hearth furnaces, according to the U.S. Steel Corp. The manganese contained in open-hearth slags amounts to about 772,000 tons p.a. and would be more than enough to compensate for the loss of Soviet supplies. All three processes have proved to be technically feasible and, as work progresses, each will be scaled up to determine whether it is commercially practicable. Two of the processes are being tested with the help of the U.S. Bureau of Mines. The third is being developed at the Armour Research Foundation.

New Celanese company

The Celanese Corp. of America has established a new global organisation

known as Celanese Central S.A. to provide closer liaison with the activities of foreign affiliates of the company in all countries except Canada.

Foreign affiliates of the company, other than those in Canada, are: Celanese Mexicana S.A., Viscosa Mexicana S.A., Celulosa Nacional S.A., Claracel S.A., all in Mexico; Celanese Colombiana S.A. in Colombia, and Celanese Venezolana S.A. in Venezuela.

CANADA

U.K. firm builds chemical works

The Watford Chemical Co., Ltd., London, has formed a Canadian subsidiary to be known as the Watford Chemical Co. (Canada), Ltd., with headquarters in Toronto. A plant site has been bought at Scarborough, a few miles east of the city and construction of one section of the plant is expected to be completed this month. A small corps of company technical men has been sent from England and production should be well advanced by the end of this year. The manufacturing programme includes a wide range of fatty acid derivatives, fine and heavy chemicals, pharmaceuticals and oil derivatives. The fatty acids will be of a type not at present made in Canada and normally imported from U.S.A.

Watford already has associated chemical manufacturing companies in Germany, Sweden, Holland, India and South Africa.

Oil project reaches pilot plant stage

During the past two years, the chemical engineering group of the Division of Applied Chemistry at the National Research Council of Canada, has carried out an investigation into the recovery of oil from the Alberta tar sands by fluidised coking of the sands. The section is now to occupy new premises extending through two stories to allow room for semi-industrial apparatus. These new premises are part of a four floor building measuring 300 x 60 ft., which is being erected to allow the Division of Applied Chemistry room for expansion.

International conferences

August 20-27. Twenty-ninth Meeting of the Australian and New Zealand Association for the Advancement of Science, Sydney, Australia.

August 20-28. Eighth International Congress on Theoretical and Applied Mechanics, Istanbul, Turkey.

August 25-30. Meeting of the Union of Pan American Engineering Societies, New Orleans, U.S.A.

August 25-September 2. General Assembly of the International Union of Theoretical and Applied Mathematics, Istanbul, Turkey.

September 1-5. International Symposium on Combustion, Cambridge, Massachusetts, U.S.A.

September 3-10. Annual Meeting of the British Association for the Advancement of Science, Belfast, N. Ireland.

September 3-15. World Power Conference, Meeting of International Executive Council, Chicago, U.S.A.

September 4-7. General Assembly of the Association of German Engineers, Stuttgart, Germany.

September 4-9. Second International Congress on Analytical Chemistry, 1952, Oxford. Three main lectures by Dr. C. J. van Nieuwenburg, Professor of Chemistry, Delft Technical University, Holland; Dr. L. H. Lampitt, chief chemist and director, J. Lyons & Co. Ltd.; and Dr. Ralph H. Müller, Los Alamos Scientific Laboratory. Under the patronage of International Union of Pure and Applied Chemistry.

Organisations convening meetings of interest to chemical engineers and chemists are invited to send full details at least two months in advance to the Editor, **CHEMICAL & PROCESS ENGINEERING**, 17 Stratford Place, London, W.1. After August 22: Stratford House, 9 Eden Street, London, N.W.1. No charge is made for publication of such details.

Recent publications

Continuous solvent extraction plant.

A new plant has recently come into operation at the British Extracting Co. Ltd. mills at Bromborough. It extracts the oil from groundnut kernels by methods which allow the protein in the residual meal to be used for the production of the new wool type fibre, *Ardil*. The complete plant is described and illustrated in a special publication by the makers, Rose, Downs & Thompson Ltd., which details the process from the pre-treatment and pressing to the separation of solvent and oil.

Rotary vacuum filters.

For the filtration of many materials in the chemical industries, mining, paper and pulp mills, International Combustion Ltd. have produced their *Rovac* filters, which are described in their booklet (No. G. 521). The range of models include rotary vacuum filters, cell filters, *Endflow* filters, and a salt filter. This filter dries crystalline materials in one operation by means of steam or electrically heated air currents.

Single roll breakers

For the sizing of ash, coal, coke, fireclay, gas oxide, caustic soda and other friable materials, are described by British Jeffrey-Diamond Ltd. in their publication 1438 D. There are seven models in both classes with seven identical breaker size measurements. All these models can be arranged for flat belt, 'V' rope or direct gear drive. The breaker is compact in design and will fit into new or existing crushing and screen plants. Segments, wearing liners, and bearings are all accessible and can be quickly replaced when required.

Continuous centrifuges.

The separation of immiscible liquids, the recovery of solids from liquids and the clarification of liquids entails the use of a centrifuge. In their publication 152-2500, Sharples Centrifuges Ltd. describe their laboratory super centrifuge. Specifications of two models are given. No. 1A, motor driven, has a maximum speed of 23,000 r.p.m. and produces a centrifugal force of 13,200 times gravity. No. 1A, turbine driven, has a maximum speed of 50,000 r.p.m. and produces a centrifugal force of 62,000 x G.

Plastics for Industry is the title of a brochure from Resinoid and Mica Products Ltd., which surveys various methods of moulding plastic articles. It includes a comparative chart outlining the relevant properties of the different types of plastics used in industry.

Stainless Steel Specifications

In the report on the symposium on 'Stainless Steel Specifications' which appeared in our June issue and which was supplied to us by the official reporter, certain remarks regarding the attitude of stainless steel manufacturers are attributed to Mr. M. M. Hallett (col. 1, p. 306). Mr. Hallett asks us to state that these remarks were not made by him but by another speaker. We regret this error.

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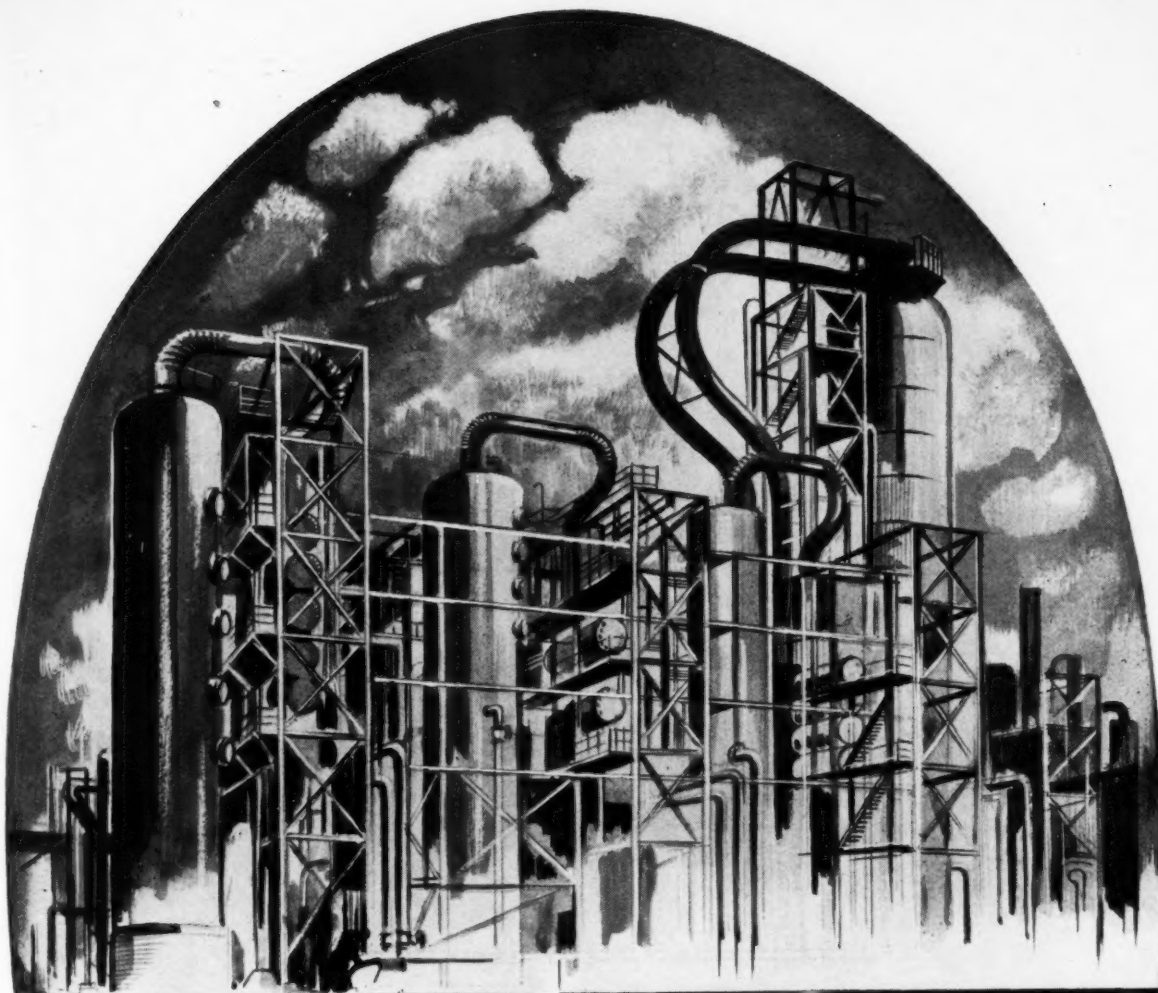
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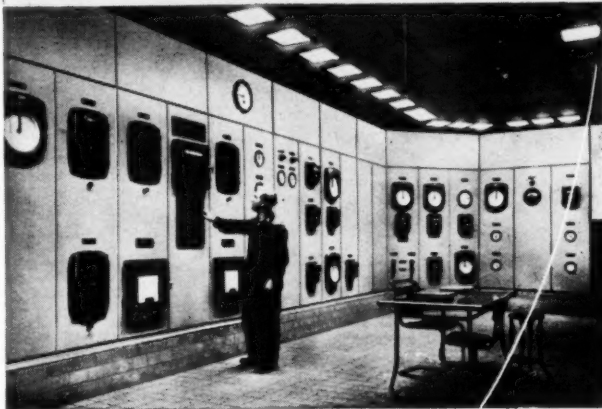
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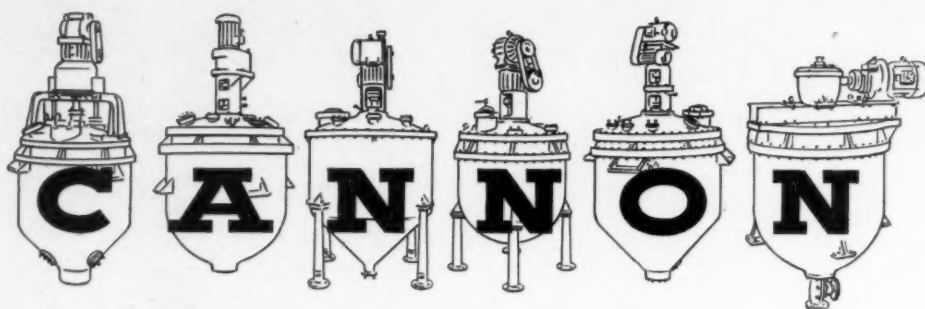
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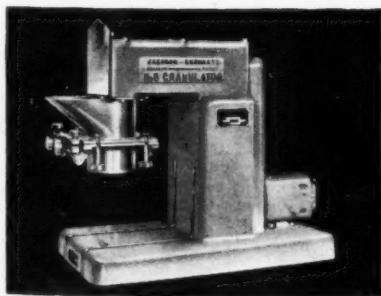
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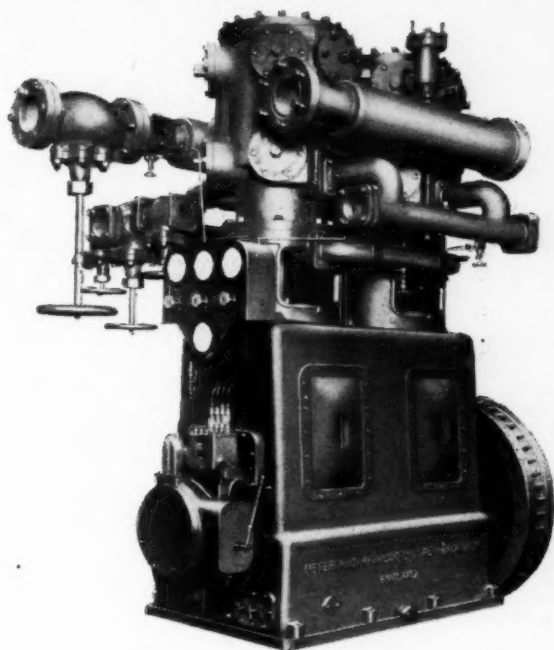
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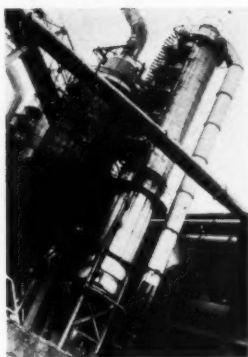
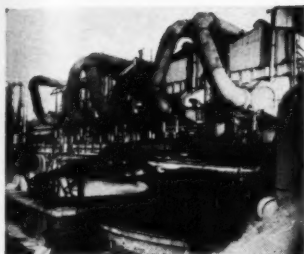
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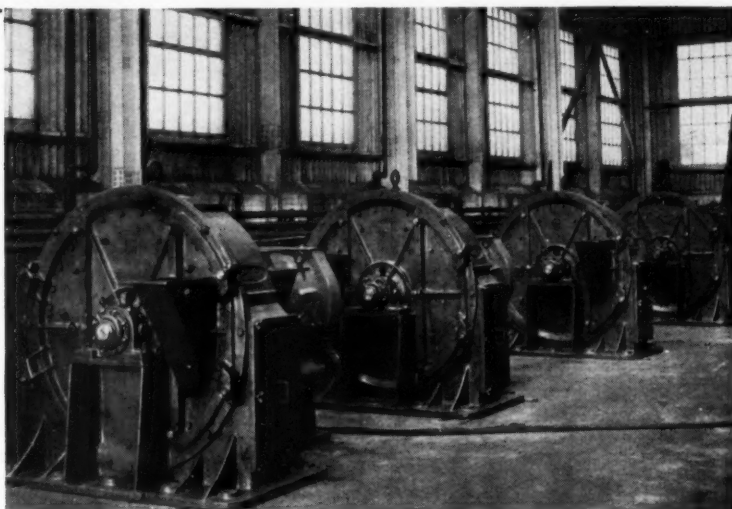
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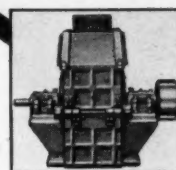
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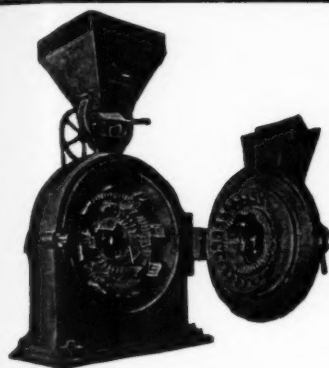
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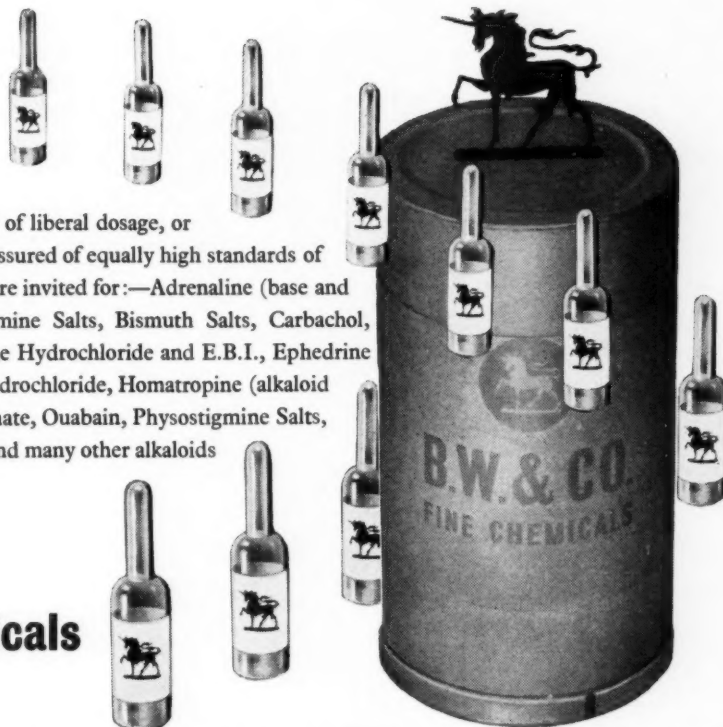
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